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Geographic Information Systems–Transportation ISTEA Management Systems Server-Net Prototype Pooled Fund Study: Phase B Summary

Juan Espinoza, Jr., Craig D. Dean, Hillary M. Armstrong, David R. Fletcher, Thomas Henderson

Prepared by
Sandia National Laboratories
Albuquerque, New Mexico 87185 and Livermore, California 94550

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Juan Espinoza Jr., Craig D. Dean, Hillary M. Armstrong
Decision Support Systems Software Engineering Department
Sandia National Laboratories
P.O. Box 5800
Albuquerque, NM 87185-1138

David R. Fletcher
Alliance for Transportation Research
University of New Mexico
1001 University Blvd. SE, Suite 103
Albuquerque, NM 87106-4342

Thomas Henderson
New Mexico State Highway and Transportation Dept.
1120 Cerrillos Road, SB-3
Santa Fe, New Mexico 87504-1149

Abstract Follows

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Abstract

The Geographic Information System-Transportation (GIS-T) ISTEA Management Systems Server Net Prototype Pooled Fund Study represents the first national cooperative effort in the transportation industry to address the management and monitoring systems as well as the statewide and metropolitan transportation planning requirements of the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA). The Study was initiated in November 1993 through the Alliance for Transportation Research and under the leadership of the New Mexico State Highway and Transportation Department. Sandia National Laboratories, an Alliance partner, and Geographic Paradigm Computing, Inc. provided technical leadership for the project.

In 1992, the Alliance for Transportation Research, the New Mexico State Highway and Transportation Department, Sandia National Laboratories, and Geographic Paradigm Computing, Inc., proposed a comprehensive research agenda for GIS-T. That program outlined a national effort to synthesize new transportation policy initiatives (*e.g.*, management systems and Intelligent Transportation Systems) with the GIS-T server net ideas contained in the NCHRP project "Adaptation of GIS to Transportation." After much consultation with state, federal, and private interests, a project proposal based on this agenda was prepared and resulted in this Study. The Geographic Information System-Transportation ISTEA Management Systems Server Net Prototype Pooled Fund Study addresses common issues in applying GIS-T to transportation planning activities.

The general objective of the Study was to develop GIS-T server net prototypes supporting the ISTEA requirements for transportation planning and management and monitoring systems. This objective can be further qualified to:

- Create integrated information system architectures and design requirements encompassing transportation planning activities and data.
- Encourage the development of functional GIS-T server net prototypes.
- Demonstrate multiple information systems implemented in a server net environment.

This Study incorporated Information Engineering and Object-Oriented Analysis methods to define integrated information systems. The Study consisted of three distinct but interrelated phases. Each phase emphasized a different aspect of the research and involved teams with different complementary skills.

The System Architecture Phase (A) focused on defining an information system architecture consistent with Federal Rules 450 and 500 of the ISTEA. This Information Engineering-based architecture consists of high level descriptions of business processes, data, and their interactions. States can use this architecture as the framework for integrated management systems development.

The Analysis and Design Phase (B) analyzed the information framework defined in Phase (A) using the Object-Oriented Analysis methodology. An object

model was developed describing efficient and effective transportation planning that take into account four different perspectives simultaneously; physical, spatial, functional, and temporal. Transportation systems and their components may be integrated and analyzed by their physical characteristics, their location and proximity to each other, the services they provide, and their relationships over time. The object model currently meets the requirements of ISTEA but it is extensible and can be adapted to provide the infrastructure planning necessary for military logistics needs.

The Demonstration Phase (C) coordinated a set of exemplary demonstrations illustrating the models developed in Phases (A) and (B). The Phase C study team, and the public and private sector partners developed demonstrations for display at the end of the study.

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SUMMARY REPORT

June 19, 1995

BACKGROUND

The first phase (Phase A) of the GIS-T/ISTEA Pooled Fund Study developed a comprehensive information framework for States and Metropolitan Planning Organizations to use in multi-modal, multi-jurisdictional transportation planning. This information framework provides a high-level view of the activities, data and business systems necessary for transportation planning consistent with the ISTEA and related Federal Rules. This policy driven framework provides a mechanism to coordinate all aspects of transportation planning. It creates the groundwork for more detailed analysis and information systems development to be conducted by individual agencies, the private sector, and subsequent phases of the Study. The Pooled Fund Study Steering Committee accepted the framework in June, 1994 and authorized the Study Team to proceed with Phase B. The Steering Committee further directd that the Study Team concentrate on analysis of the Functionally Integrated Transportation System (FITS).

The Study Team subsequently met with representatives from the private sector sponsors in July, 1994 in order to clarify the objectives, scope and deliverables of Phase B. Several issues were resolved during that session and have been incorporated into this Phase Plan:

1. The Transportation Planning Enterprise Model is an overall architectural specification and NOT an information system specification. Consequently, the first tasks of Phase B were to focus on a detailed systems analysis of the Functionally Integrated Transportation Business System (FITS) defined in Phase A. Emphasis was to be placed on further defining the problem domain; that is, WHAT data and operators are required and not on HOW the methods should or will be implemented. System design activities in the later stages of Phase B were to be limited to the design of demonstration objects only, as opposed to the design of a FITS information system.

2. Because the Study Team changed methodologies from Information Engineering to Object Oriented Analysis, tutorial materials will need to be developed and distributed to the Study sponsors.

3. A mid-Phase review activity was added to the Project Plan to allow States and corporate sponsors to contribute to the work in progress. This release of draft

specifications would allow system developers to move ahead with their individual design initiatives.

The Mission of the Study Team for Phase B was defined as follows:

> "Our mission is to provide guidance to the transportation information systems community by developing an Object Oriented information systems architecture for the Functionally Integrated Transportation System (FITS)."

SUMMARY OF RESEARCH ACTIVITY

The Study Team began Phase B in August, 1994 by participating in a week-long training course in Object Oriented Analysis conducted by the Advanced Concepts Center of Martin-Marietta Corporation. The purpose of the course was to bring the entire Phase B Team up to the same basic level of understanding of object analysis before proceeding into the technical work.

The Phase B Team met for nine working sessions, each typically one week long. A great deal of additional time was spent by the Team off line in preparing for the sessions, addressing action items identified in the sessions, researching background material, and documenting results.

Presentations to the sponsors of the work in progress were made through an Interim Release mailed in January, 1995 and at a special one-day session prior to the AASHTO ISTEA Management Systems Workshop in Kansas City, Missouri on February 25, 1995. Regular monthly Status Reports were also mailed to the sponsors.

The final results of Phase B were presented to the Steering Committee on April 1, 1995 at Sparks, Nevada. The Steering Committee confirmed that the work met their expectations for Phase B and provided guidance to the Study Team on Phase C.

SUMMARY OF FINDINGS

Perspectives

The key finding produced in Phase B was that transportation must be viewed from four different perspectives simultaneously to support efficient and effective transportation planning:

- Physical

  What physical components exist that support transportation, and what are their characteristics and condition?

- Spatial

  Where are the transportation components located, both geographically and linearly, and what is their proximity and connectivity to other components?

- Functional

  What services do components and systems provide in meeting transportation needs?

- Temporal

  How do the components and systems change over time?

Integration across the four perspectives may be achieved incrementally. The first step of Physical-Spatial integration uses co-location as the strategy for correlating the physical states of transportation components (e.g., pavements, fixtures, bridges, etc.). Physical components are combined into component systems based upon proximity and connectivity. Geographic Information Systems (GIS) are a logical technology to support this level of integration because of their spatial foundation. A simplified translation of Physical-Spatial integration is that it determines the state of "things" between "here and there."

The second step toward comprehensive integration is the Spatial-Functional where functional similarity becomes the strategy for integrating performance. The performance of components and systems is determined by specialized sets of services that provide for the movement of freight or people between origins and destinations. Examples of sets of specialized services are those that might support recreation or the movement of oversize vehicles. Demand is then combined according to function. In other words, this level of integration determines the performance of "things" between "here and there."

The final integration step is Functional-Temporal where time becomes the strategy for determining whether or not performance objectives are being met. While implementation of this step is the most challenging in the incremental integration approach, this level may be simply described as determining the change in "things" over time between "here and there."

Evaluation of Object Oriented Methodology

A secondary, but significant, finding of Phase B is that Object Oriented Analysis proved extremely helpful in clearly analyzing the problems involved in moving the Phase A information architecture into preliminary design. It was equally helpful, and quite

powerful, in modeling the solutions to those problems. The key elements of object modeling that proved so useful are:

- o Encapsulation

  Defined objects package together procedures with its corresponding data. For example, a bridge element object might combine its condition with the method that is used to measure that condition.

- o Inheritance

  Hierarchical classes of objects allow lower level classes to "inherit" the methods and characteristics used by higher level classes. For example, the high level object "structure" might have an attribute called "Date of original construction" which would be inherited by the lower level "bridge" or "retaining wall" objects without having to be repeated as an attribute within those objects.

- o Complexity Management

  By using encapsulation, inheritance, and additional object techniques such as the abilities to use abstract classes of objects and to "nest" objects within objects, otherwise extremely complex environments may be modeled without the model collapsing from unmanageable detail or convoluted internal relationships. Decision support systems are examples of this kind of complexity.

The object modeling software selected by the Study Team for use in Phase B, OMTool by Rumbaugh, et al., was found to be adequate to support the Rumbaugh Object Modeling Technique. The OMTool does a good job of technical documentation; however, it is deficult to turn the reports into a document immediately useful to domain experts. The developers of OMTool have recently announced that it will be replaced by a more robust object modeling tool in mid-1995. A recent Sandia National Laboratories survey revealed that there are now a significant number of CASE tools supporting the Object Oriented Methodology and specifically the Rumbaugh Object Modeling Technique notation.

The object approach allowed Team B to develop insights which would not have been possible if traditional information engineering methodologies had been used. The idea of the "complex" object for managing both physical and functional systems is one of those insights.

SUMMARY OF CHALLENGES

While the Study Team did not uncover insurmountable technical obstacles to moving these ideas forward into prototyping, there are definitely challenges associated with the results.

These are identified below and grouped according to increasing levels of challenge. The terms used are consistent with the names of objects in the Phase B Model.

Spatial Integration

- Reference sites and sections by a specific linear reference method to a specific linear network, then to at least one cartographic base
- Support the derivation of the attributes of one component from the characteristics of spatially coincident components (e.g., ride derived from pavement condition and traffic volume for a particular location)
- Derive statistical profiles based on topologic relationships
- Support route concurrency (two or more traversals in the same system sharing the same transport link) and aliasing (two or more traversals in different systems sharing the same transport link)
- Support non-contiguous routes
- Support the intersection of sites and sites as well as sites and sections (e.g., crashes and rail crossings, crashes and traffic sections)

Functional Integration

- Connect sites, sections, and routes to form networks or systems based on a transport function (e.g., intermodal assembly)
- Given an origin and destination for a transport function, determine all possible traversals through a network
- Given a traversal, determine the cost of using that traversal given user-supplied parameters or a cost function. Also, determine the lowest-cost traversal
- Given total movement through a transport system, allocate the total movement to individual components based on component capacities
- Support subsystems (e.g., subsetting a state highway system into regions or municipal areas) and supersystems (e.g., assembling highway components of commuter systems and recreation systems into a total highway system)
- Integrate reference networks with non-linear features such as planning regions, environmental areas, land use areas, demographic areas, etc.

Temporal Integration

- Maintain multiple experiences for each transportation component. Given any state, components must reveal the times they were in that state. Given a time, components must reveal their state

- Maintain temporal consistency. At any given time, all transportation components must be able to reveal their state

- Maintain temporal coincidence. Objects may reveal themselves at a given time only when they exist at that time

- Support time-series analyses on the experiences of a transportation component over its lifespan

- Support transforming events into transportation component experiences

- Maintain transportation systems over time or recreate the same transportation systems" at different times (as in assessing the results of hypothetical treatments)

- Support moving a transportation component backward or forward through chains of experiences to reveal its state. This implies the support of valid time (present) as well as planning time (past and future)

- Support subsetting of transportation components by time interval (e.g., identify all abandoned railroads from 1970-1995)

Linear referencing

- Support association of a single linear reference method with a single geographic resolution

- Support associating a single linear reference method with multiple geographic resolutions

- Support associating multiple linear references with a single geographic resolution

- Support associating multiple linear references with multiple geographic resolutions. An example of this would be to support simultaneous access to accident data at 1:100,00 scale using route/mile point and accident data at 1:200 scale using intersection/offset

- Support for extensibility; i.e., adding new linear reference methods or new geographic resolutions should not entail changing the software

Complexes

- Support a single-spectrum data container without concern for data modification or component validation. Given a location interval, the container must return component information for that interval that includes geographic extent and value

- Support adding (validating) new components and deleting (invalidating) existing components

- Support linear resectioning based on new data and marking old (revised) sections as invalid

- Support time as another spectrum. This must include both sectioning and membership of sections and components as a function of time

- Support flexible linear referencing in the complex. For example, allow for implementing two different complexes using two different linear references, or implementing a single complex using two or more linear references

- Provide experience processing within the complex

Time and Experience

- Given a specific transportation component, define different allowable experiences for that transportation component. Given a specific transportation component, apply an experience to that transportation component

- Given a transportation component initial state and a sequence of allowable experiences, show the transportation component state after the application of each experience

- Roll back through past experiences and show the transportation component states before and after each experience

Encapsulation of Legacy Systems

- Identify the best approaches to transitioning from existing systems to the new multi-perspective model

- Identify the level of resources in terms of people, time, training, and budget that will be required to make the transition

Design of an Organization-specific Version of the Model

- Identify the transportation components, systems, complexes and attributes and methods that are appropriate for a specific organization

Simultaneous Time/Space Topology Management

- Maintain topologic relationships in both space and time simultaneously for all pairs of objects in the database. Approaches:
  (1) Maintain the relationships explicitly and persistently in the database
  (2) Maintain the relationships through a combination of explicit and implicit representations
  (3) Dynamically determine the relationships

- Support viewing space as a subset of time and systems as subsets of space

Planning Workbench Capabilities

- Component Management:
  (1) Add/remove sites (accounting for time)
  (2) Add/remove sections (accounting for time)
  (3) Add experiences
  (4) Aggregate/remove components in component groups (e.g., all components of Bridge 204)
  (5) Determine state of component

- Complex Management:

  (1) Add/remove/modify components in a complex
  (2) Establish reporting methods for complexes (e.g., compute average values over multiple sections)

- System Management:
  (1) Select complexes and systems
  (2) Establish multi-spectral measures
  (3) Allocate travel demand
  (4) Determine state of systems
  (5) Evaluate performance of systems
  (6) Determine need of systems

- Scenario Management:
  (1) Name a scenario
  (2) Add experiences to a scenario
  (3) Remove experiences from a scenario

- Planning
  (1) Select a planning scenario
  (2) Establish Workbench initial time
  (3) Establish view of data
  (4) Establish Workbench time step(s)
  (5) Establish Workbench geographic planning area

DEFINITIONS

Complex
A collection of interconnected transportation components. Complexes are used to manage groups of components, i.e., act as "containers." They are the primary mechanism for determining multicomponent performance, e.g., pavement sections may collaborate with the traffic section complex.

Component
An object regarded as part of a transportation system.

Component System
A transportation system composed of transportation elements.

Element
Any transportation related object that affects or monitors the availability, quality or performance of transportation functions or services.

Event
An isolated instant in time. An event is said to occur at time "t" if it occurs at any time during the chronon represented by "t."

Experience
An event participated in. Significant experiences are those that change object states.

Geographic Planning Area
A set of spatial objects that represent the location of a planning area at some cartographic scale and resolution.

Goal
A specific, measurable performance target of a tansportation objective.

Intermodal System
An ordered set of transportation components from more than one mode or means of transportation.

Linear references
The location of a site relative to a traversal in some system. A linear reference object is a container of linear locations represented by traversals and their reference point sites.

Need
The difference between the performance of a transportation system and a transportation goal.

Objective
A statement of direction and extent for the availability, quality or performance of transportation.

Performance
The functional effectiveness of a transportation component.

Planning Event
A unit of planning activity that, when complete, leaves the enterprise in a consistent state.

Planning Region
An entire planning area, usually either a metropolitan planning region or statewide region.

Planning Scenario
A hypothesized chain of experiences.

Planning Workbench
The planning workbench is the mechanism for accessing - through a single, consistent interface - all of the objects defined by the transportation planning business systems architecture.

Reference Network
A frame of reference, or datum, used to control linear locations. The reference network is used for both field locations and data base representations of those locations.

Section
A linear portion of a transportation system or its components defined as the portion of the component located between two sites.

Site
A transprtation component that exists or occurs at a specific place.

State
A condition of being defined by constant attributes and link relationships. A state can be thought of as a portion of time between events. A State with no end state is current when valid time equals system time.

Transport System
A transport system is an ordered collection of transportation components serving a transportation function in support of transportation objectives. These systems can be single mode (e.g., highway systems), multimodal (e.g., public transportation buses plus light rail), or intermodal (e.g., freight or passenger based). The default transport system consists of all transportation choices within a predetermined region.

Transportation System
An ordered set of transportation components.

Travel Demand
The actual or latent movement of people or freight between two points for a specific purpose. Each trip (or aggregation of trips) is characterized by mode choice.

PHASE B ANALYSIS AND PRELIMINARY DESIGN TEAM

Mr. Craig Dean (Team B Leader)
Sandia National Laboratories
Organization 9403, MS 0777
Albuquerque, New Mexico 87185

Mr. David Fletcher, President
Geo-Digm Computing, Inc.
5018 Odana Road
Madison, Wisconsin 53711

Mr. John Espinoza
Sandia National Laboratories
Organization 9604, MS 0767
Albuquerque, New Mexico 87185

Mr. Thomas Henderson, P.E.,L.S.
Geometronics Unit Manager
New Mexico State Highway and
Transportation Department
1120 Cerrillos Road, SB-3
Santa Fe, New Mexico 87504-1149

Ms. Hillary Armstrong
Sandia National Laboratories
Organization 6641, MS 0718
Albuquerque, New Mexico 87185

Ms. Ann Hodges
Sandia National Laboratories
Organization 9432, MS 0977
Albuquerque, New Mexico 87185

Mr. Len Malczynski
Sandia National Laboratories
Organization 6904, MS 0722
Albuquerque, New Mexico 87185

Ms. Amy Maxsted
Sandia National Laboratories
Organization 9411, MS 0977
Albuquerque, New Mexico 87185-0767

REFERENCES

"Foundational Concepts of Phase B." Internal Phase B Working Document, December, 1994

"Highway Location Reference Methods." NCHRP Report 21. National Research Council, Washington, D.C., 1974.

Humplick, F. and Paterson, W., "Framework of Performance Indicators for Managing Road Infrastructure and Pavements." Third International Conference on Managing Pavements, San Antonio, Texas, 1993.

"Phase B Interim Release." Internal Phase B Working Document distributed to the Steering Committee in January, 1995.

"Report on the Results of a Workshop on a Generic Data Model for Linear Referencing Systems (Draft)." Work in Progress Report on NCHRP Project 20-27(2), Madison, Wisconsin, 1995.

Rumbaugh, J., Blaha, M., Premerlani, W., Eddy, F., and Lorensen, W., Object-Oriented Modeling and Design. Prentice Hall, Englewood Cliffs, New Jersey, 1991.

"Spatial Archive and Interchange Format: Formal Definition." Release 3.1. British Columbia Specifications and Guidelines for Geomatics. Surveys and Resource Mapping Branch, Ministry of Environment, Lands and Parks, Province of British Columbia, Canada, 1994.

Taylor, David A., Object Oriented Technology: A Manager's Guide. Addison-Wesley, Reading, Massachusetts, 1990.

GEOGRAPHIC INFORMATION SYSTEMS - TRANSPORTATION
ISTEA MANAGEMENT SYSTEMS
SERVER NET PROTOTYPE POOLED FUND STUDY

PHASE B PROJECT PLAN

September 15, 1994

BACKGROUND

The first Phase of this Pooled Fund Study, sponsored by the

- US Federal Highway Administration,
- US Federal Transit Administration,
- Sandia National Laboratories,
- 40 State Departments of Transportation,
- District of Columbia and
- nine private sector companies,

has developed a comprehensive information framework for States and Metropolitan Planning Organizations to use in multi-jurisdictional, multi-modal transportation planning. This framework consists of a set of information models incorporating the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) requirements for statewide and metropolitan planning activities (23 CFR 450) plus the requirements for seven management and monitoring systems (23 CFR 500):

- highway pavement,
- bridges,
- highway safety,
- traffic congestion,
- public transportation facilities and equipment,
- intermodal transportation facilities and systems and
- traffic monitoring for highways.

The information framework developed in Phase A provides a high level view of the activities, data, and business systems necessary for multi-jurisdictional, multi-modal transportation planning consistent with the ISTEA and related Federal Rules. This policy driven framework provides a mechanism to coordinate all aspects of transportation planning. It creates the groundwork for more detailed analysis and information systems development to be conducted by individual agencies, the private sector and subsequent phases of the Study. The framework is inherently flexible and can be adapted to a wide range of individual implementation and operational choices

across all organizations involved in transportation planning activities. The Pooled Fund Study Steering Committee accepted the framework in June 1994 and authorized the Study Team to proceed with Phase B.

The Study Team subsequently met with representatives from the private sector sponsors in July, 1994 in order to clarify the objectives, scope and deliverables of Phase B. Several issues were resolved during that session and have been incorporated into this Phase Plan:

1. The Transportation Planning enterprise model is a overall architectural specification and NOT an information system specification. Consequently, the first tasks in Phase B will focus on a detailed systems analysis of the Functionally Integrated Transportation Business System (FITS) defined in Phase A. Emphasis will be placed on further defining the problem domain. That is, WHAT data and operators are required and not on HOW the methods will or should be implemented. System design activities in the later stages of Phase B will be limited to the design of demonstration objects only, as opposed to the design of a FITS information system.

2. Because the Team is changing methodologies (from Information Engineering to Object Oriented Development), tutorial materials will need to be developed and distributed to the Study sponsors.

3. A mid-Phase review activity has been added to the project plan to allow States and corporate sponsors to contribute to the work in progress. This release of draft specifications will allow systems developers to move ahead with their individual design initiatives. In addition to this release, work in progress materials will be posted in an Internet anonymous ftp space. Access information will be provided when available.

MISSION:

Our mission is to provide guidance to the transportation information systems community by developing an Object Oriented information systems architecture for the Functionally Integrated Transportation System (FITS).

OBJECTIVES:

The objectives of this Phase are to:

1. Analyze and define the functional and data requirements for FITS.

2. Develop a preliminary design of the Phase C demonstration that illustrates some of the principles, methods, requirements and architectures developed in Phases A and B of this Study.

3. Evaluate the effectiveness of using an Object Oriented Development methodology in the analysis and design of geographically based transportation information systems.

4. Transfer knowledge and experience about Object Oriented Development to the Study sponsors.

SCOPE:

As directed by the Steering Committee, Phase B will focus on analyzing information system requirements for FITS (Attachment A). FITS encompasses those activities and data that create and maintain functionally derived transportation systems, determine demand for the services provided by each system, and assess the performance of each system relative to the objectives and goals established for these services.

The FITS system manages the inventory of all transportation facilities and services, where these components are functionally, geographically and temporally related. These facilities and services are organized into unique, dedicated systems delivering specific transportation services (e.g., traffic carrying, load bearing, employer access, farm-to-market access, asset service life) in response to social policies, objectives and goals. Each of these transportation systems experiences current and projected demand for services; each is affected by this demand. The FITS system manages both the demand for service and the performance of the systems responding to this demand.

Phase B will not emphasize the system design objects involved with dialog management, security, message handling or other production issues. It is also outside the scope of this Phase to identify or design the specific methods necessary to implement the transportation system travel demand operators (i.e., trip generation, trip distribution, modal split and traffic assignment).

DELIVERABLES:

1. FITS ANALYSIS

    a. Problem Statement (especially as it relates to FITS) defining functional requirements and architectural requirements including implementation standards recommendations.

    b. An Object model identifying pertinent modules (intermediate packaging units for complexity management) containing object classes and operators derived from the Phase A enterprise model. Attributes and operators of all superclasses will be derived and documented. Examples of some subordinate classes will be developed.

c. A Dynamic Model consisting of a collection of state diagrams representing the behavior of instances of an object class with respect to a sequence of events. State diagrams for all superclasses will be derived and documented.

d. A Functional Model identifying the major data transformations, especially as they relate to FITS.

2. A Demonstration Preliminary Design that may include examples of specific methods, user interface prototypes, or system messages.

3. An evaluation of the Object Oriented Analysis and Design methods used in this Phase.

4. A Tutorial on Object Oriented Analysis and Design using OMT.

5. A set of recommendations concerning the remainder of the Study.

Note: Phase B will *NOT* deliver a FITS information system design. This decision was made at the June 1994 meeting of the Steering Committee policy and reaffirmed at the vendor's workshop

PROJECT SCHEDULE:

A detailed Phase Schedule is included as Attachment B. Phase B Activities will begin August 1994 and will be completed by mid January 1995. Preliminary results of the analysis will be distributed to the Steering Committee in early November for review and revision. A second interim Steering Committee meeting is scheduled for the end of February 1995.

ASSUMPTIONS:

1. The Linear Location data model developed during the National Cooperative Highway Research Program Project 20-27 Workshop on Linear Location Reference Systems - August 1994, will be reviewed and incorporated into the FITS model, as appropriate.

2. The mid-Phase analysis review opportunity will result in refinements to the analysis, rather than a significant change of direction.

DEFINITIONS

Framework - An enterprise wide information architecture consisting of formal models of data, activity and their interaction.

Information Engineering - The enterprise-wide application of a formal and structured

3. Evaluate the effectiveness of using an Object Oriented Development methodology in the analysis and design of geographically based transportation information systems.

4. Transfer knowledge and experience about Object Oriented Development to the Study sponsors.

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DEFINITIONS

Framework - An enterprise wide information architecture consisting of formal models of data, activity and their interaction.

Information Engineering - The enterprise-wide application of a formal and structured

methodology for defining and implementing information systems which derive directly from the enterprises's objectives. Source: James Martin.

Information System - The combination of Information Technology, data, business procedures and people applied to a business function, process or activity.

Information Technology - Computer hardware, software and technical staff necessary to develop, implement, maintain and operate information systems.

Management System - A systematic process, designed to assist decision makers in selecting cost-effective strategies/actions to improve the efficiency and safety of, and protect the investment in, the nation's infrastructure. A management system includes: Identification of performance measures; data collection and analysis; determination of needs, evaluation and selection of appropriate strategies/actions to address the needs, and evaluation of the effectiveness of the implemented strategies/actions. Source: DOT 49 CFR Parts 500 and 626 Management and Monitoring Systems; Interim Final Rule.

Object Modeling Technique (OMT) - An Object Oriented Development methodology developed by J. Rumbaugh et. al.

Object Oriented Development - An approach to (information) systems development in which each component represents an object in the real world. These objects are encapsulated with attributes that describe the object, plus possible actions that can be taken upon the object and its attributes. Source: Stephen Montgomery, *Object Oriented Information Engineering.*

REFERENCES:

Sections 1024, 1025, 1034 and 3012 of the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA), Pub. L. 102-240, 105 Stat. 1914, 1977 amended Title 23, USC.

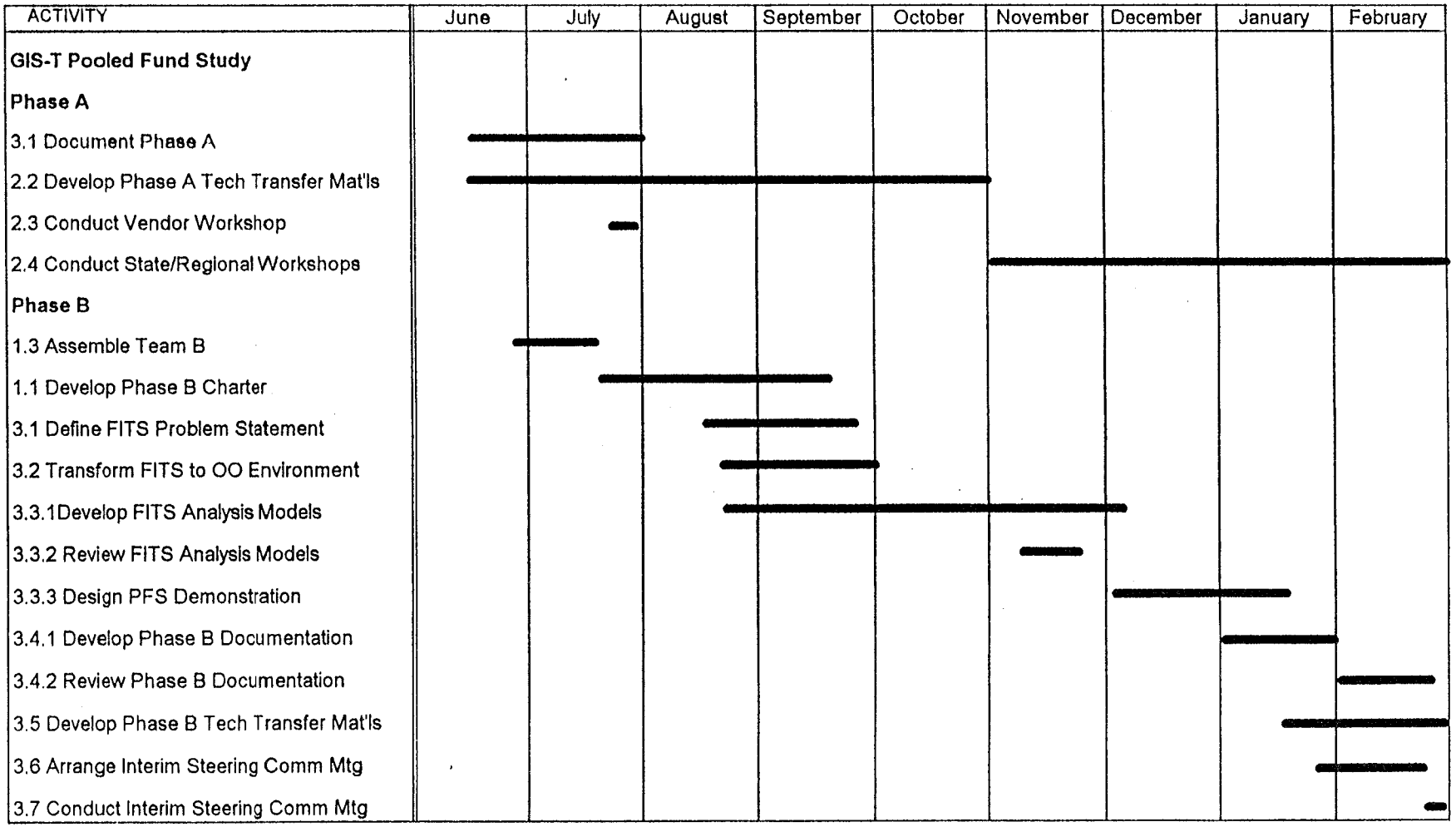
Geographic Information System - Transportation ISTEA Management Systems Server Net Prototype Pooled Fund Study Proposal and Project Plan, November 1993.

Geographic Information System - Transportation ISTEA Management Systems Server Net Prototype Pooled Fund Study Phase A Summary Report, June 1994.

Rumbaugh, James, Micheal Blaha, William Premerlani, Frederick Eddy and William Lorenson. *Object-Oriented Modeling and Design* (englewood Cliffs, NJ: Prentice Hall) 1991.

GIS-T Pooled Fund Study

PHASE B PROJECT PLAN
September 15, 1994



PHASE B -FITS ANALYSIS and DESIGN TEAM:

David Fletcher Co-Principal Investigator
Geographic Paradigm Computing, Inc.

Tom Henderson Co-Principal Investigator
New Mexico State Highway and
Transportation Department

John Espinoza Co-Principal Investigator
Craig Dean Team B Leader

Hillary Armstrong
Ann Hodges
Len Malczynski
Amy Maxted
Sandia National Laboratories

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1.0 Introduction

1.1 Tutorial Scope

This tutorial presents an introduction to object-oriented (OO) technology. The goal is to provide the reader with enough knowledge about OO so that the results of Phase B of the GIS-T Pooled Fund Study can be understood and used by the study sponsors.

1.2 Intended Audience

The intended audience for this tutorial is the study sponsors. The sponsors consist of both software system developer and transportation planners.

1.3 Related Reading and Training

The Advanced Concepts Center at Martin Marietta offers several OMT classes. Team B members took Object-Oriented Analysis in 8/94. This course is best suited for system developers. Call 1-800-438-7246 for further information about other classes and schedules.

The references section contains an annotated list of references. The following table summarizes the references, and suggests a roadmap, where appropriate, for further reading. The additional reading, with several exceptions, aren't necessary to understand the Phase B results.

TABLE 1. Additional Reading

For Information About	Audience	See Reference
Read this first: Background on Phase A study - section 1	everybody	[gist94]
Read this second, if you're new to OO: Excellent starting point for gaining basic understanding of OO - well illustrated, inexpensive, quick reading (~1/2 day)	everybody	[tayl]
Overview of OO methodologies	developer	[mona92]
Executive overview of OO methodologies	transportation planner	[harm94]
OO tool support	developer	[harm94]
Details on OMT	developer	[rumb91]
Latest info on OO and vendors	developer	[joop], [obj]
Directory of OO-related languages, companies, consulting firms, products, services, ...	developer	[ioop]
Another OO tutorial - contained in section 2	everybody	[saif94]

2.0 Background

2.1 Motivation for Object Oriented Methodology

The focus of Phase B of the GIS-T Pooled Fund Study is the Functionally Integrated Transportation System (FITS). FITS maintains the basic inventory of transportation infrastructure and the functional transportation systems as defined by policy objectives.[1] The reasons for using an object oriented approach are:

- **Natural Description:** The components making up this system are easily described as objects with associated operations and functionality.
- **Flexibility:** The GIS-T ISTEA Management System must be adaptable to any transportation planning organization, be adaptable across many technologies, and maintain its policy driven nature. Object oriented technology provides this flexibility. The section on ***Key OO Concepts*** provides more details on how this level of flexibility is attained.
- **Reuse Other Work:** Other work, such as the resulting model out of the Linear Reference Workshop and the [saif94] model, can be incorporated more easily as both models are described using OO techniques.

2.2 Motivation for Object Modeling Technique (OMT)

There are approximately 23 different varieties of object-oriented approaches, each of which differs in descriptive support. There are two main reasons why OMT was chosen.

- **Descriptive Power:** [mona92] and [harm94] compare the OOAD methodologies and list OMT as one of the richest in descriptive power and comprehensive support for large-scale projects.
- **Tool Support:** [harm94] indicates that OMT has the widest tool support.

2.3 Implications for Phase A Work

Phase A work was described using Information Engineering (IEF). The transformation from IEF to an OMT description is relatively straightforward, since the models in the IEF methodology are a subset of the three models which are used in the OMT methodology. The correspondence between views in the IEF and OMT models will be pointed out in the ***Object-Oriented Analysis/Design*** section.

1. [gist94], page 6.

3.0 Object Oriented Analysis/Design

3.1 Introduction

Analysis or Design??

The distinction between analysis and design can be blurred. Analysis deals with problem definition - it addresses WHAT. Design focuses on the solution definition - more details about WHAT and HOW. Some of the HOW facets include interface, resource, control, data structures, and algorithms.

To answer the question posed in the heading for this section, BOTH! Phase B will include a more detailed analysis of FTTS and a preliminary design of the Phase C demonstration using OMT.

3.2 Key OO Concepts

There are several key ideas that form the foundation of OO technology. These ideas aren't necessarily unique to OO methodologies, but are well supported by OO.

3.2.1 Abstraction

Abstraction is a way to deal with complexity. This concept permits concentration on a problem at some general level of detail, and ignoring details which aren't at that level of generalization. Each level of detail is known as a *level of abstraction*. Let's consider roadways. Figure 1 shows an overall picture of the roadway network. Each roadway is represented as a line, and the engineering details of each segment are unnecessary for this high level view. This is at a higher level of abstraction than the engineering view of the roadway shown in Figure 2.

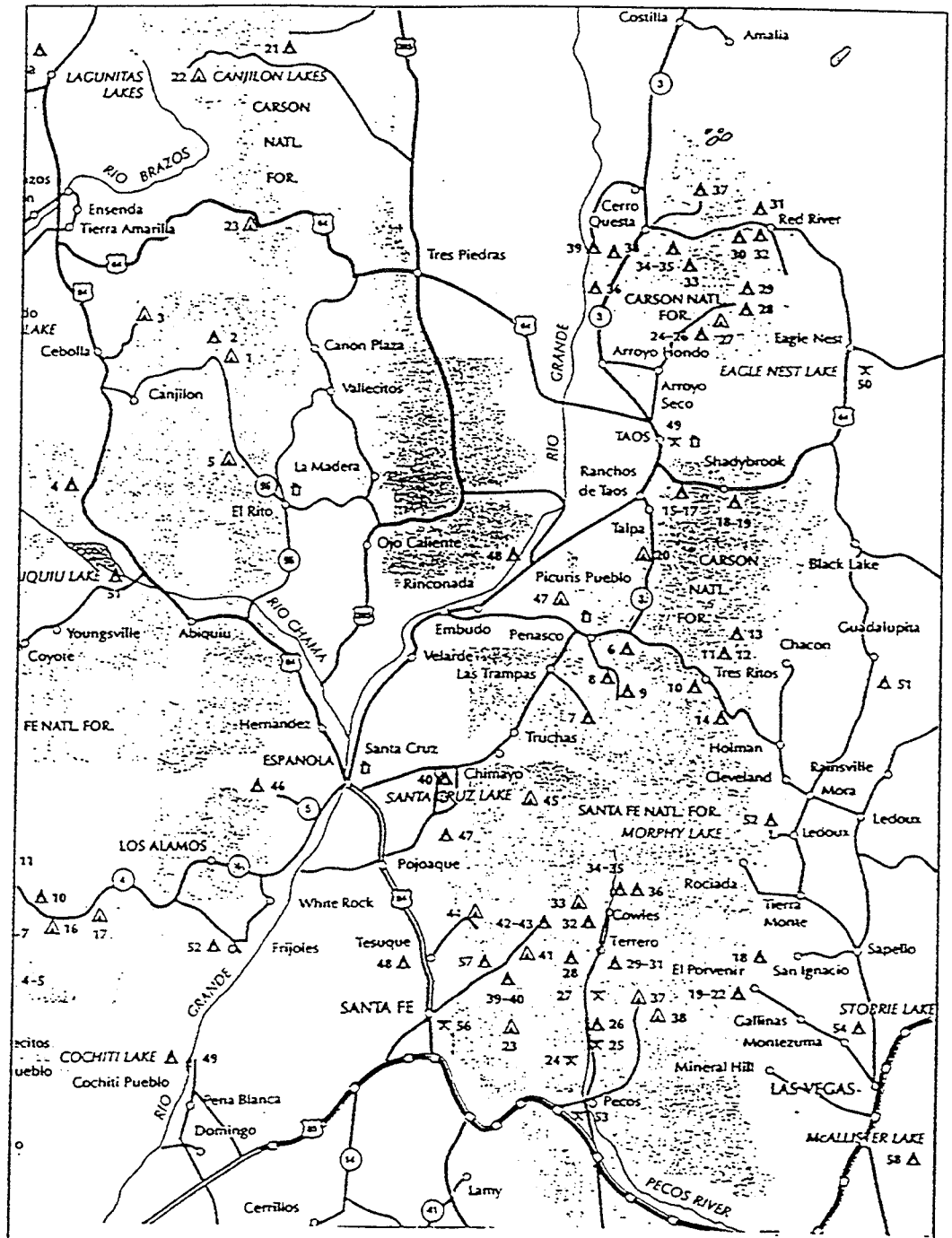

Figure 1: Overall View of Roadway Network

Each phase in the software development lifecycle specifies further detail, and is thus a lower level of abstraction. Modern programming languages typically provide some data

abstraction capability. Fewer provide functionality abstraction. OO technology provides both data and functionality abstractions.

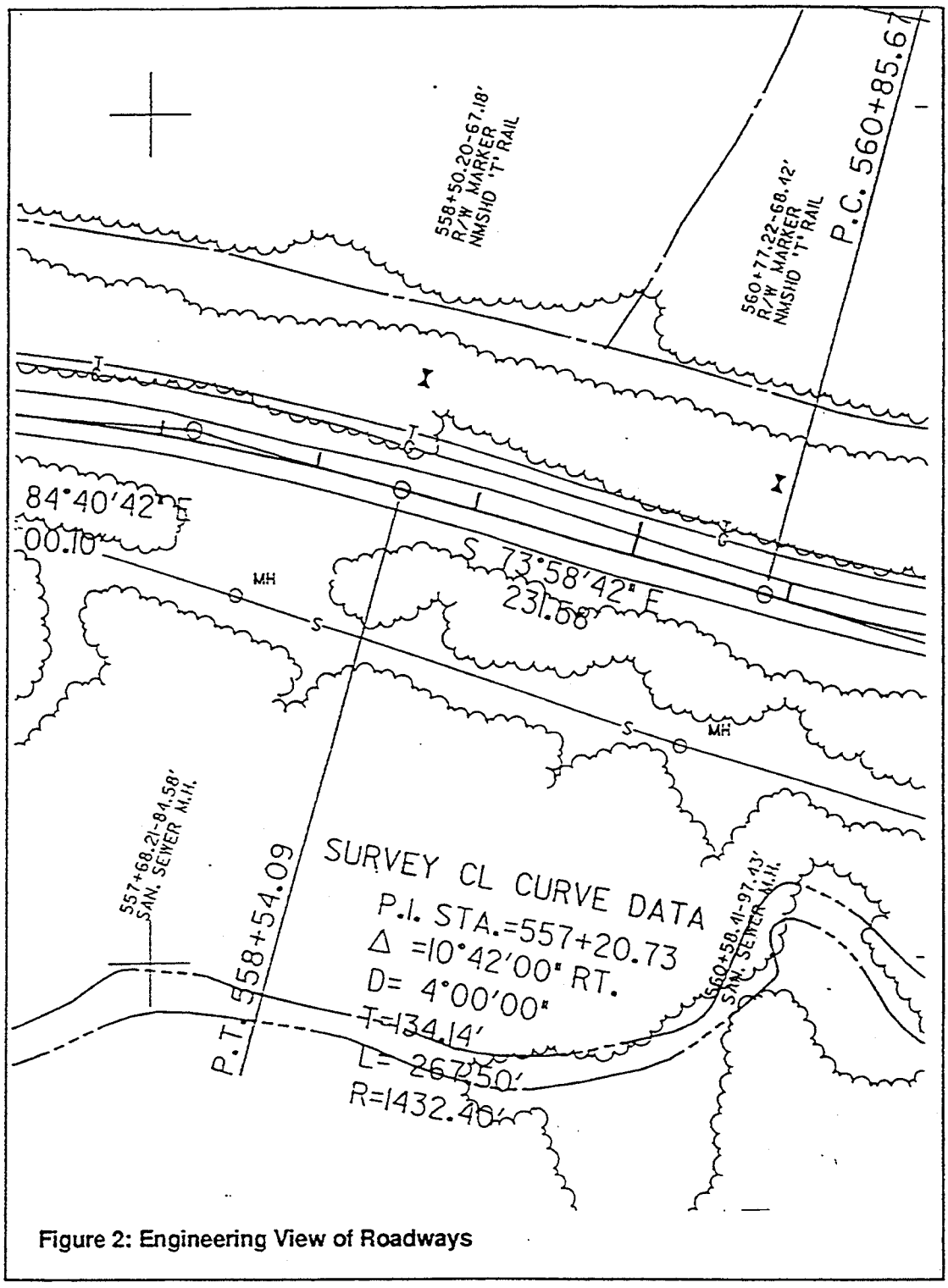

Figure 2: Engineering View of Roadways

In OO methodology, an *object* is an abstraction of a thing in the problem domain (described during analysis) or the solution domain (part of design specification). An object can be physical, e.g. the Rio Grande bridge in Albuquerque, NM, or something less tangi-

ble like Objective from the Phase A study. All objects have an identity and are distinguishable from one another.[1] For example, two sections of pavement may look identical, but are separate. A higher level of abstraction is a *class*, which is a set of objects with behavior, attributes and relationships in common.

3.2.2 Encapsulation

This concept is also known as information hiding. This means that internal details of some entity (object in OO terms) are hidden from outside scrutiny and can be reused by referencing that entity. This is another approach to managing complexity. In OO technology, an object contains data (i.e. the attributes and values that define an object), and functions (operations that change the object's attributes) and other relevant information (e.g. other objects in the case of an object composed of other objects) in a package, or encapsulates this information. Encapsulation allows a function to take different forms in different objects, which is known as *polymorphism*. For example, the function "drive" is different for cars with automatic versus standard transmissions, which is again different from a tractor trailer. Then to "drive" these vehicles, all the user needs to specify from an OO standpoint might be speed and direction, not the operational driving details. See Figure 3 for a general example of a motor vehicle object. The motor vehicle data, shown in the interior circle, is changed by the functions in the outer square.

1. [rumb91], page 22.

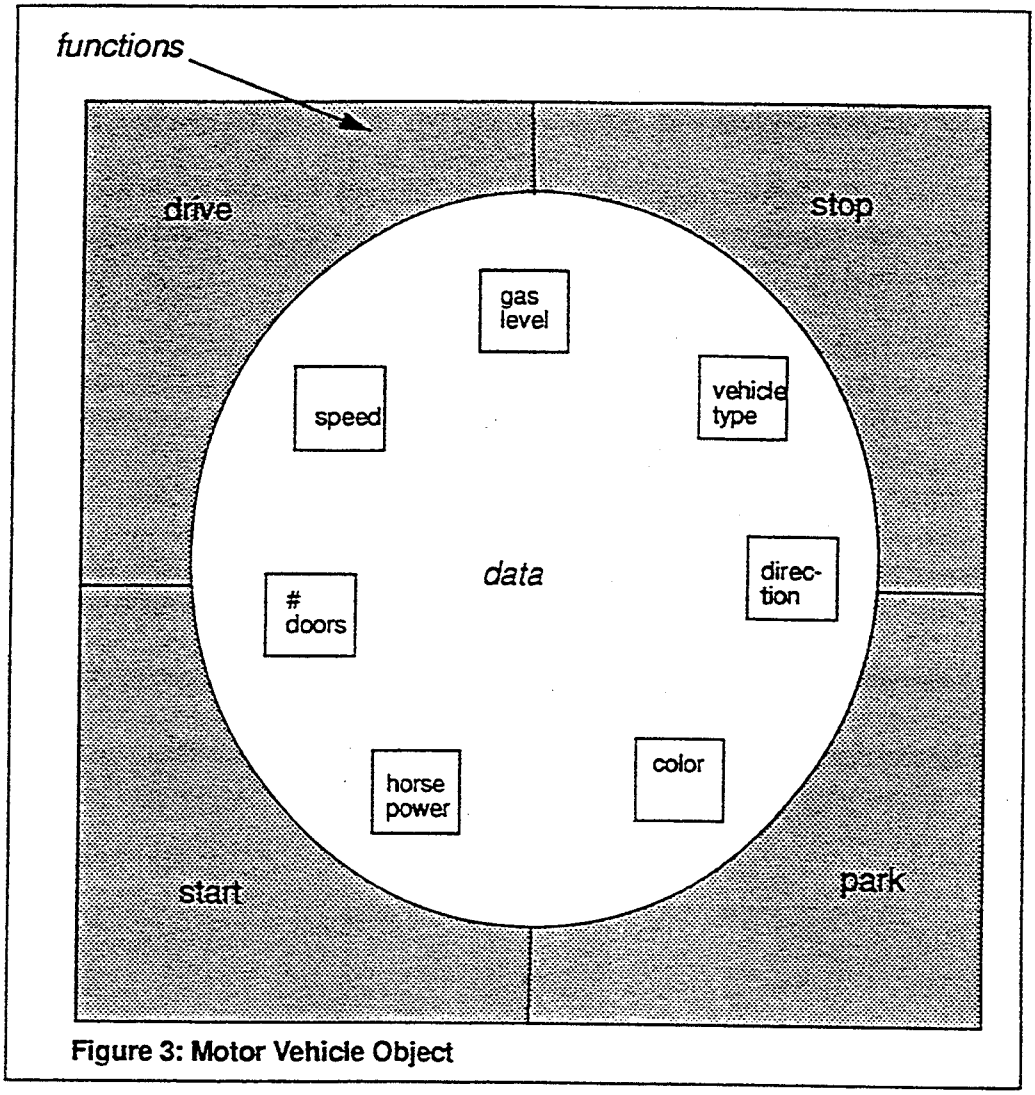

Figure 3: Motor Vehicle Object

3.2.3 Inheritance

The object class hierarchy allows attributes, behavior and relationships to be shared by members of the hierarchy. For example, the motor vehicle object represents a class of objects which share the common attributes and functions shown in Figure 3. Some typical members of the class might include an automatic transmission car, standard transmission car, and the tractor trailer. Classes within the same hierarchy can have behaviors that are customized for each class within that hierarchy. As discussed in the previous section, this is known as *polymorphism*. The "drive" function is different for each of the types of motor vehicles.

3.3 Three OMT Models

OMT describes a system using three models. Each of these models provides a different perspective on the system being modeled. These models cross-reference each other. Each model will be described in subsequent chapters of this tutorial.

Object Model - explains the structure of the objects and their relationships to other objects. The object structure includes the attributes and operations that modify those functions.

Dynamic Model - describes the control part of the system. This model is specified by a *state machine*, which is simply a graph containing object *states* (shown as nodes) and *movement between states* (shown as arrows) caused by *events*. The state machine can also be expressed as a table.

Functional Model - specifies how data is changed in the system. This model is described by a *data flow diagram* which is a graph containing *processes* (shown as nodes) that work on the *data* (shown as arrows) as it flows through the system.

The IEF activity and data models from Phase A corresponds to the OMT object model. The IEF business systems model corresponds to the functional decomposition of the OMT model into *modules*, which serves to manage complexity. This concept will be described later in the tutorial.

4.0 Bibliography

4.1 Books, Reports, and Articles

[gist94] *Geographic Information Systems-Transportation ISTEA Management Systems Server-Net Prototype Pooled Fund Study - Phase A System Architecture Summary Report*, 7/12/94. This is the output from the Phase A study. Read section 1 to gain a basic understanding of the system architecture. The rest of the report contains the detailed IEF model, which is more useful for system developers.

[harm94] P. Harmon editor, *Object-Oriented Strategies*, monthly newsletter for managers and developers of OO systems, vol. 4, # 5, 5/94. This is one of the overview articles on OO. Contains a comparison of methodologies. Read this to gain an understanding of tool support. More of an executive overview than [mona92].

[mona92] D. Monarchi, G. Puhr, *A Research Typology for Object-Oriented Analysis and Design*, CACM, vol. 35, #9, 9/92. Very nice treatment on the various OO methodologies. May be more useful for system developers. Read [harm94] for more of an executive overview.

[rumb91] J. Rumbaugh et al, *Object-Oriented Modeling and Design*, G.E. Research and Development Center, Prentice Hall, 1991, ISBN 0-13-110439-X. This is *the* definitive source on OMT. Read this if you're wearing your developer's hat.

[saif94] *Spatial Archive and Interchange Format: Formal Definition*, British Columbia Specifications and Guidelines for Geomatics, vol. 1, 4/94. Contains an OO tutorial section.

[tayl] Taylor, *Object Oriented Techniology:A Manager's Guide*, ISBN 0-201-56358-4. This contains a good executive overview on OOl.

4.2 Periodicals

[ioop] *International Object-Oriented Programming Directory*, SIGS Publications. Contains a directory of OO-related languages, consulting firms, products, book list, events, articles and case studies.

[joop] *Journal of Object-Oriented Programming*, SIGS Publications. Contains latest thinking/advice on OO, and vendor information.

[obj] *Object Magazine*, SIGS Publications. Contains OO articles and vendor information.

5.0 Glossary

abstraction - Concentration on a problem at some general level of detail and ignoring details which aren't at that level of generalization.

behavior - Operational characteristics. See **operation.**

class - A set of objects with behavior, attributes and relationships in common.

class hierarchy - A hierarchy of classes. See **class.**

encapsulation - Hiding the internal details - also known as information hiding.

FITS - Functionally Integrated Transportation System

GIS-T - Geographic Information System - Transportation

IEF - Information Engineering Facility

ISTEA - Intermodal Surface Transportation Efficiency Act - legislation passed in 1991.

inheritance - Attributes, behavior and relationships are shared by members of the object class hierarchy.

method - Implementation of an operation. See **operation.**

OMT - Object Modeling Technique

OO - Object-oriented

object - Abstraction of a thing in the problem domain or the solution domain.

operation - An action that an object performs or is subject to.[1]

Phase A - First phase of the GIS-T ISTEA Management Systems Pooled Fund Study.

Phase B - Second phase of the GIS-T ISTEA Management Systems Pooled Fund Study.

Phase C - Third phase of the GIS-T ISTEA Management Systems Pooled Fund Study

polymorphism - An operator may behave differently across classes - e.g. the print operator is different for graphics vs. text.

Team A - Personnel working on the Phase A study.

Team B - Personnel working on the Phase B study.

1. [rumb91], page 2.

Chapter 2: The Object Model

1.0 Introduction

The obect model is the first OMT model built in the OO analysis/design process. This model explains a system's structure by showing:

- the system's objects
- the object's relationships to each other
- attributes (data) and operations with each object class

This chapter discusses only the concepts needed to understand the FITS object model. Refer to [rumb91] for a more complete description of the OMT method.

2.0 Basic Concepts

2.1 Objects and Classes

Recall from the previous chapter that an *object* is an idea, abstraction or something that's meaningful in the system's context. Objects are typically nouns in the problem statement document. There is no one right way to represent the problem. Each object can be uniquely identified. For example, two bridges may have identical superstructures, decks and substructures, but are still individual instances. A *class* is a higher level of abstraction, which represents a set of objects with operations, attributes and relationships in common.

An object model is shown graphically in an *object diagram*. An example of a class and some objects representing instances of that class are shown in the diagram in Figure 1.[1]

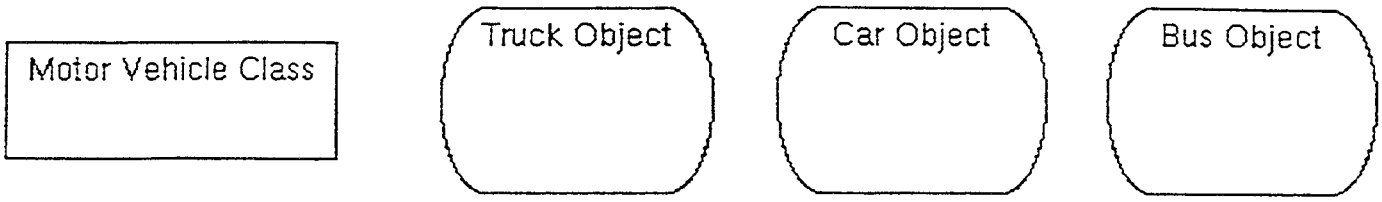

Figure 1: Example of class and objects

2.2 Attributes and Operations

Each object has attributes that define it, and operations that modify those attributes. Figure 2 shows how attributes and operations are represented in a diagram for the motor vehicle class from chapter 1. Attributes are in the section below the class or object name, and operations are in the last section under attributes.

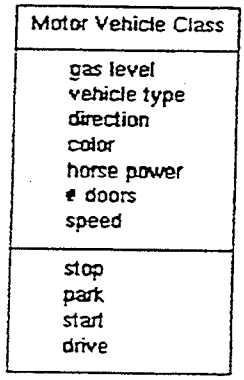

Figure 2: Example of class diagram with attributes and operations

1. All diagrams are generated with OMTool, the PC-based version of OMT.

2.3 Relationships

A relationship is some type of meaningful connection between object classes or instances. For example, Trn_System *is-impacted-by* Trn_Sys_Travel_Demand, where *is-impacted-by* is the named relationship. This relationship is shown graphically in the following figure by a line annotated with the relationship name. A relationship can be "read" from the graphic in both directions, although it is normally stated directionally. Reading the relationship illustrated in figure 3 in the opposite direction would be: Trn_Sys_Travel_Demand *impacts* Trn_System.

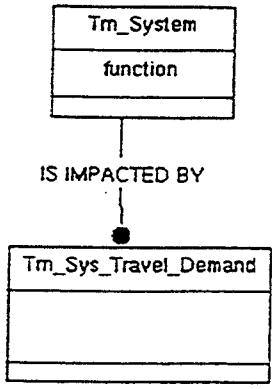

Figure 3: Relationship between Object Classes

[rumb91] distinguishes relationships between object classes and object instances. An *association* is a relationship between classes, where a *link* is a relationship between instances. The rest of this tutorial will use the general term relationship. Where object classes and instances are typically nouns in problem statement documents, relationships are verbs.

2.3.1 Multiplicity

Multiplicity indicates the number of instances that one class may be in a relationship with a single instance of another associated class. The default multiplicity is "one-to-one", that is one instance in one class is related to one instance in the other class. The curious reader may have noticed the solid dot on the relationship line by the Trn_Sys_Travel_Demand class in figure 3. This means that many (zero or more) demands can impact one transportation system (a "many-to-one" relationship).

2.3.2 Generalization

Generalization is the relationship between a class and one or more specific versions of that class - "a-kind-of" relationship. The more general class is called the *superclass*, and the

specific versions are known as *subclasses*. An example of a small class hierarchy from the Transportation System module (module will be defined shortly) is shown in figure 4. Trn_System is the superclass with respect to its subclasses made up of Impact_Funct_Trn_System, Mobility_Funct_Trn_Sys and Srvc_Life_Funct_Trn_Sys.

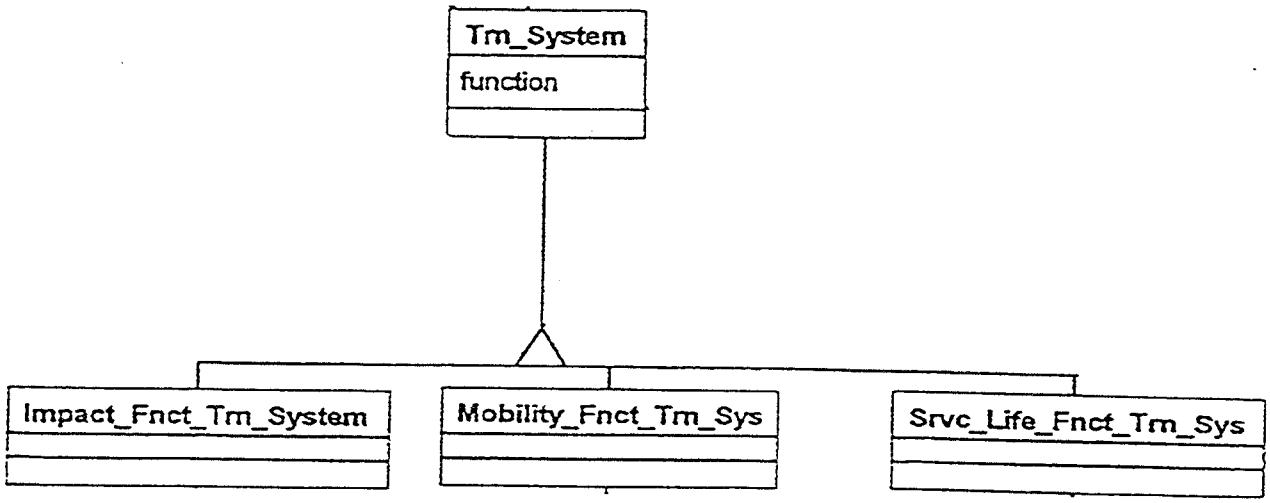

Figure 4: Generalization Example

The operations and attributes of a superclass are inherited by its subclasses. Each subclass can have its own specific attributes and operations as well.

2.3.3 Aggregation

Aggregation is another special relationship - "a-part-of". This represents the components' relationship to the object corresponding to the whole assembly, e.g. a bridge's superstructure, deck and substructure components to the bridge. Figure 5 shows an example of an aggregation notation in OMT. Properties (attributes and operations) of the assembly may pass down to the components, with changes as required.

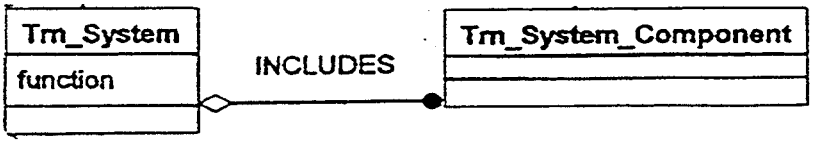

Figure 5: Aggregation Example

2.3.4 Link Attribute

A relationship can have one or more attributes associated with that relationship. Recall from an earlier section that a link is an instance of a relationship. Therefore, a link attribute is a relationship instance that has an attribute. The attributes of that relationship can be combined into a class rather than contained in one of the classes in that relationship. Figure 6 shows how a link attribute is represented in the information model. System_State is the link attribute object.

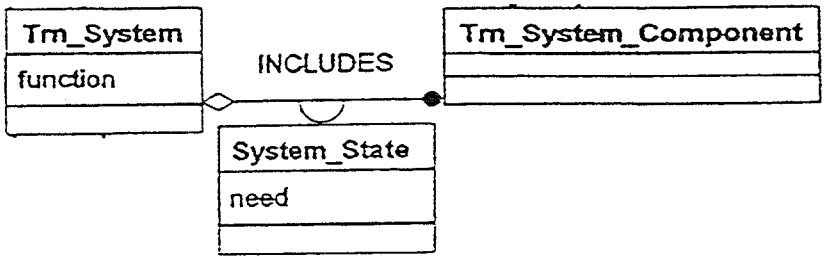

Figure 6: Link Attribute Example

2.4 Complexity Management

Complexity management is crucial in modeling a complex system. It supports grouping the model logically into different views or subgroups.

Module is a form of structural complexity management in OMT. Classes and relationships are grouped together to represent a particular view of the system. There should be more relationships within a module than between modules. The FITS modules identified so far include the Global Model, Transportation System, Transportation System Component, and Topological/Geographic Model.

A class may appear in several modules. This is the way that modules are bound together. Team B calls this a *socket*, and this allows other information models to be essentially "plugged into" the FITS model, e.g. a spatial object model (SDTS or SAIF).

2.5 Test Scenarios

Scenarios were prepared which represent typical uses of the system being modeled. The scenarios are useful in a number of different ways:

- **adding detail:** May suggest attributes and operations, which tests the current class hierarchy structure.

- **extending the model**: May point out missing objects and relationships.
- **regression testing**: If the information model changes, the model must still support the "queries" represented by the scenarios.
- **coverage testing**: Some portion of the information model supports the "queries" represented by the scenarios. For those portions of the model not "hit" by the queries, the scenarios may not be extensive enough, or maybe that portion of the information model is unnecessary.
- **design and implementation**: Scenarios represent typical usage of the system, which may point out design and implementation choices needed at run-time. A good source for demo material, as well.
- **dynamic model**: Forms the basis for the next model which illustrates the time-dependent/control behavior of the system.

Scenarios were developed from a variety of state planning and strategy documents ([ordot94], [njdot94]), the ISTEA regulations, the FHWA ISTEA course ([fhwa94]), state DOT and MPO intermodal planning issues identified in [ismarta], and discussions with transportation experts ([ismartb], [kyte94]). These scenarios represent a rich mix of rural, and urban transportation planning problems and issues. The scenarios are included in the information model delivery.

2.6 Data Dictionary

A data dictionary in the OMT world contains descriptions for each object class, which includes special constraints and assumptions. Attributes, operations and relationships are included as well.

3.0 Object Modeling Process

The Phase B team used the following process to develop the FITS object model. This is an adaptation of the steps appearing in [rumb91][1].

1. Identify objects and classes. A rich source for the team was the Phase A IEF model.
2. Eliminate redundant classes.
3. Identify relationships.
4. Identify class hierarchies.
5. Group classes into modules.
6. Test and refine the model. Additional classes are found from source material listed in the reference section at the end of this chapter. Typically, these are found by generating test scenarios from goals and associated performance measures in the source documents. Additional potential scenarios (uses of the system) are discussed in meetings with other domain experts, such as Ken Kyte, NJ DOT, and Dane Ismart, FHWA Project Leader of Intermodal Planning. These are also "walked through" the FITS object model to verify that it can support the "query". Design questions are identified during this step, with alternatives and recommended solution to present to the team.
7. Object instances are generated from the test step. The instances contain attributes (criteria associated with the goal) and operations.
8. Further refine the model. The attributes and operations may suggest an adjustment is needed in the class hierarchy.
9. Prepare the data dictionary.

1. Page 152.

4.0 Bibliography

4.1 Books, Reports, and Articles

[fhwa94] FHWA and FTA, *Congestion Intermodal and Public Transportation Management Systems - Training Course for Managers*, NHI Course # 15262, 3/94.

[ismarta] D. Ismart, Project Leader of Intermodal Planning, FHWA, *State DOT and MPO Intermodal Planning Issues.*

[njdot94] *Candidate NJ Transportation System Performance Measures.*

[ordot94] Dye Management Group, Inc. et al, *Intermodal Management System Scope Development, Metro - Oregon DOT - Port of Portland*, 4/22/94.

[rumb91] J. Rumbaugh et al, *Object-Oriented Modeling and Design*, G.E. Research and Development Center, Prentice Hall, 1991, ISBN 0-13-110439-X. This is *the* definitive source on OMT. Read this if you're wearing your developer's hat.

[tayl] Taylor, *Object Oriented Techniology:A Manager's Guide*, ISBN 0-201-56358-4. This contains a good executive overview on OO.

4.2 Meetings

[ismartb] D. Ismart, Project Leader of Intermodal Planning, FHWA, meeting with GIS-T Pooled Fund Study Team B, 10/20-21/94.

[kyte94] K. Kyte, NJ DOT, meeting with GIS-T Pooled Fund Study Team B, 9/19-20/94.

5.0 Glossary

abstraction - Concentration on a problem at some general level of detail and ignoring details which aren't at that level of generalization.

aggregation - "a-part-of" relationship.

association - A relationship between object classes as opposed to object instances. See **relationship.**

attribute - Features of an object.

behavior - Operational characteristics. See **operation.**

class - A set of objects with behavior, attributes and relationships in common.

class hierarchy - A hierarchy of classes. See **class.**

complexity management - Supports group the information model into different views or subgroups.

data dictionary - Contains descriptions for each object class, which includes special constraints and assumptions. Attributes, operations and relationships are included as well

encapsulation - Hiding the internal details - also known as information hiding.

FITS - Functionally Integrated Transportation System

generalization - "a-kind-of" relationship.

GIS-T - Geographic Information System - Transportation

IEF - Information Engineering Facility

ISTEA - Intermodal Surface Transportation Efficiency Act - legislation passed in 1991.

inheritance - Attributes, behavior and relationships are shared by members of the object class hierarchy.

link - A relationship between object instances.

link attribute -A relationship instance that has an attribute. The attributes of that relationship can be combined into a class rather than contained in one of the classes in that relationship.

method - Implementation of an operation. See **operation.**

module -A form of structural complexity management. Classes and relationships are grouped together to represent a particular view of the system.

multiplicity - Indicates the number of instances that one class may be in a relationship with a single instance of another associated class.

OMT - Object Modeling Technique

OO - Object-oriented

object - Abstraction of a thing in the problem domain or the solution domain.

object diagram - Graphical representation of an object model.

operation - An action that an object performs or is subject to.[1]

Phase A - First phase of the GIS-T ISTEA Management Systems Pooled Fund Study.

Phase B - Second phase of the GIS-T ISTEA Management Systems Pooled Fund Study.

Phase C - Third phase of the GIS-T ISTEA Management Systems Pooled Fund Study

polymorphism - An operator may behave differently across classes - e.g. the print operator is different for graphics vs. text.

relationship - Some type of meaningful connection between object classes or instances.

socket - A class may appear in several modules. This is the way that modules are bound together. Team B calls this a *socket*, and this allows other information models to be essentially "plugged into" the FITS model, e.g. a spatial object model (SDTS or SAIF).

subclass - More specific class in the generalization relationship.

superclass - More general class in the generalization relationship.

test scenario - Represent typical uses of the system being modeled.

Team A - Personnel working on the Phase A study.

Team B - Personnel working on the Phase B study.

1. [rumb91], page 2.

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Transportation Planning Information Systems Requirements Analysis[1]

Introduction

This document describes a transportation planner's view of a decision support environment designed to support the transportation planning functions defined in the Transportation Planning Business Systems Framework[2]. The purpose of this analysis is to present a structured framework that can be used as a starting point or template in many concurrent development efforts. The ideas expressed in this model are intended to be used as a general requirement's framework; they do NOT represent a complete and comprehensive specification as presented. Differences among the study's sponsors preclude a "one-size fits all" specification.

The model will need to be extended in several ways before actual software development can take place:

1. The model contains incomplete classes, attributes, and operations. Existing object classes will need site specific attributes and methods defined. State and local planning groups must still select suitable performance measures and indicators. Object characteristics shown have been extracted from the relevant Federal Regulations and are included solely for exemplary purposes[3].
2. In most designs, further specialization of the class hierarchies will need to occur.
3. Additional associations between subclasses may be necessary to reflect detailed performance relationships.
4. The analysis concentrated on objects in the transportation planning domain. Command and control objects (*e.g.*, security, GUI's) and other system solution domain objects will need to be added to the problem domain classes provided. These may differ depending on the targeted technical hardware and software environments.

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[1] This Object Model Narrative describes the fits6 Module dated March 29, 1995. The Object Model was developed in OMTool 2.0 using the Object Modeling Technique developed by Rumbaugh, *et al.*

[2] This Framework is described in the GIS–T/ISTEA Management Systems Pooled Fund Study Phase A Summary Report, June 1994. The analytic model encompasses the data and processes included in the FITS, TRAMMS, PASS and part of the TREADS business systems.

[3] This model is consistent with DOT 23 CFR Part 450 Statewide Planning; Metropolitan Planning; Rule and with DOT 23 CFR Parts 500 Management and Monitoring Systems; Interim Final Rule.

Overview

The general requirement for this system is that it must accommodate the information needs of a large, diverse set of customers:

- from different disciplines (*e.g.*, policy makers, planners, and engineers);
- from different sectors (*e.g.*, public and private);
- with different resolutions (*e.g.*, urban and rural);
- with different time frames (*e.g.*, long range planning, and short term programming);
- with differing responsibilities (*e.g.*, program managers and project managers).

Any system that meets these needs must be able to adapt and evolve. The following discussion presents the general requirements for such a system.

Transportation Systems Planning

Transportation systems planning is a proactive response to the dynamic interplay between travel demand[4] – derived from the economic, demographic, and land use characteristics in a particular planning area – and the services provided by the transportation systems in that area [Sheet 1]. These services, and the systems that supply them, are intended to be consistent with the transportation objectives decided upon by the community. The planning process itself is cooperative, involving many agencies in the pubic (*e.g.*, state and local planning organizations) and private sectors (*e.g.*, private transit operators).

Planning areas are defined at many differing levels of detail, where smaller areas (*e.g.*, households) aggregate to larger areas (*e.g.*, travel analysis zones) and into regions (*e.g.*, metropolitan planning area) [Sheet 2]. These differing planning area levels of resolution can be used to make appropriate estimates of person and commodity movements.

Transportation Systems

Transport Systems provide basic transport access, connectivity, and capacity services through an interconnected network of transport links and nodes [Sheet 3]. Systems are distinguished by their ability to provide specific transport services in response to explicit policy objectives and performance requirements. Individual transport system instances may be based on major modal distinctions (*e.g.*, highway systems, rail systems), on minor modal distinctions (*e.g.*, truck route systems, public transportation systems) or on functional distinctions (*e.g.*, farm to market systems, just-in-time manufacturing systems, recreational travel systems). Functionally integrated transportation systems may include a number of different modal components.

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[4] In this context, travel demand includes the actual and latent demands for person and freight movements.

The transportation infrastructure consists of a number of component based systems. These systems may be distinguished by engineering similarities (*e.g.*, bridge and pavement systems) or by program area (*e.g.*, safety, traffic monitoring). Systems may also contain non-network elements such as public transportation assets [Sheet 4].

Transport systems and component systems comprise the general class of transportation systems [Sheet 5]. All transportation systems can have subsystems; all systems can be members of more complex systems. For example, the Interstate Highway System is a part of the National Highway System and contains roadway, pavement, and bridge subsystems.

Each System contains many Transportation Components (hereafter called Components) and is derived by "dissolving" away from the universe of all transport, connectivity, and infrastructure choices those components that do not contribute to the objective(s) under consideration. That is, the planner, decides what transport choices (*i.e.*, functional components) are relevant and how performance will be measured (*i.e.*, physical components). These choices limit the available components that can provide support for the particular purposes under consideration. The same component may belong to many systems. For example, the same highway link may be a part of the National Highway System, the Strategic Highway Network (STRAHNET), a freight distribution system, and so on.

Sets of components are related by two mechanisms: 1) topologically connected into transportation networks; and 2) grouped together into transportation complexes (*i.e.*, collections[5]). Each component, complex and network has geographically derived relationships (*e.g.*, adjacency or coincidence) with other components, complexes, and networks. These relationships between components are coincidental (*i.e.*, based on their linear topology) and not direct. That is, all sections are related to each other because they share common locations and not because of their common design or construction. For example, pavement sections are coincident with roadway sections. They are not considered a "part" of one (or more) roadways. The "knowledge" that roadways have about pavements (or that highways have of roadways) is established through their complex-to-complex relationships and not through a direct (*i.e.*, component-to-component) associations. In this example, a highway complex would collaborate with a pavement complex to determine the ride quality of a particular highway section which is dependent on the roughness of coincident pavement section(s).

The condition state of each System and component object changes in response to its experiences. Each object exists in one state. Over time, the experiences (*e.g.*, treatments, inspections) of the object accumulate, where each experience marks the beginning of a new object state (NOT a new object). The life span of an object (*i.e.*, the entire time that the object is known to the data base) is the time ordered sequence of all its experiences. Objects may have multiple (proposed) life spans representing alternative sequences of states.

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[5] A collection is a special kind of aggregate object that contains groups of other objects.

Transportation Components

Components are either site based or are stretches of the transportation network [Sheet 6]. These linear portions are described as sections. Sections begin or end at known sites. Each section represents a distinct instance of a link or element and has the same characteristics across its entire length. Thus, sections can be defined in one of three ways:

1. dynamically, reflecting changes in state (*e.g.*, surface distress);
2. in response to some physical event (*e.g.*, a construction treatment);
3. arbitrarily defined (*e.g.*, control sections).

Just as Systems represented functional as well as physical objects, so do Components. Functional Components (Links and Nodes) provide access and connectivity services. Physical Components (elements) provide the underlying infrastructure that determines the quality of the services.

Transportation links are defined by mode (*e.g.*, highways, railways, pedestrianways, . . .) [Sheet 7]. Links represent actual, historical, or proposed travelways between customer sites (*i.e.*, origins and destinations). Specific travel choices are made at junctions (*i.e.*, allowing change of route) or terminals (*i.e.*, allowing change of mode) [Sheet 8]. Junctions can also be used to define links based on significant physical characteristics (*e.g.*, project termini). Customer sites can be defined precisely (*e.g.*, major employer sites) or in aggregate (*e.g.*, travel analysis zones). The set of nodes as defined by the purpose of the System establishes the granularity of the links. For example, Systems that provide high degrees of access will have more nodes (and more granular links) than Systems that provide arterial services only. In other words, the sole purpose of a link is to support travel between two nodes.[6]

The transportation infrastructure consists of component elements (*e.g.*, roadways, bridges, tunnels, . . .) and performance monitoring sections (*e.g.*, safety, traffic) [Sheets 9, 10, 11]. Systems may also contain various incidental attachments associated with a system [Sheet 12] plus information about other capital assets (*e.g.*, equipment, maintenance facilities, . . .)[7]. Identification of Component-specific performance measures, indicators, and criteria are not within the functional scope of this analysis.

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[6] Travel that offers modal choices between two nodes would be represented by multiple links.

[7] Note: Although public transportation capital assets [Sheet 4] do not have a direct relationship to public transportation system performance, information concerning them is required under 23 CFR 500.607

Location Reference[8]

Transportation Systems reveal their existence through the existence of their components. That is, the Systems are de facto collections of Components with geographic characteristics. Consequently, all Components need to be located in the field as well as positioned (*i.e.*, given a coordinate value) in the database. This is accomplished by establishing a linear reference system including one or more linear reference methods[9]. All Site object locations are described by reference to a linear method(s) [Sheet 13]. As was previously discussed, since every section is bounded by a site object, locating every site will concurrently locate every section object.

All linear reference methods require the identification of a known point. An object's location is described as an offset measurement and direction of the measurement relative to this known location in some System. That is, linear locations are referenced by (and to) Transport Systems needing location data. This means that physical Component sites are referenced to modal links and nodes. Traversals define paths (*i.e.*, a set of links connected head-to-tail) through Transport Systems. Traversals (and traversal metrics) can be in any vector units (*e.g.*, distance, time, cost) and reflect official designations or usage characteristics (*e.g.*, freight distribution route) [Sheet 14]. A System location (or address) consists of a traversal (*e.g.*, route) plus a traversal reference point. That is, the location of a known point relative to a traversal through a System. Consequently, the same linear location may have many System addresses in either the same or in different systems. For example, an intersection can be a highway system reference point and a transit system bus stop.

All Systems are registered to a reference network, or linear datum, which can be represented as one or more spatial objects. This feature allows the same System to be modeled at multiple levels of resolution in geographic data bases of differing scales [Sheet 15].

Planning Workbench[10]

The transportation planner uses the Planning Workbench to conduct many of the planning processes included in the Framework's six business systems [Sheet 16]. Each elementary process is recorded as a planning event allowing the planner to track the status of the planning function or to develop planning scenarios (*i.e.*, a series of events) for "what-if" explorations. The Planning Workbench is envisioned to provide ad hoc access to an integrated, dynamic set of transportation planning objects or phenomenon. The primary ability provided by the Workbench

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[8] These ideas are derived from the results of the NCHRP Project 20-27 Location Data Modeling Workshop, August 1994.

[9] NCHRP Synthesis 21 Highway Location Reference Methods, 1974 provides additional details regarding reference systems and methods.

[10] The Workbench metaphor was provided by Ken Kyte P.E. Director, New Jersey DOT Division of Transportation Research and Data Technology.

is support for a planner's interactive exploration of the interrelationships between Systems and their environment.

All planning objects in this model are considered to be temporal and either occur at a single instant in time (*i.e.*, an event) or exist over some duration of time (*i.e.*, a state). All changes to these objects result from events. These events may be caused by the planner, where these events correspond to the elementary processes managed by the Planning Workbench [Sheets 17,18,19] or they may arise out of the direct experiences of the objects themselves [Sheet 20]. In both cases, objects are exposed to these events through their experiences. This implies that the existence and condition of an object at any time are equivalent to the state (*i.e.*, the time between two significant events[11]) of the object at that time. Put another way, if the condition (state) of an object is known, then the time frame (state) of the object is known; the reverse is also true.

In addition, because all objects are specialized states, every object has a temporal relationship with all other objects. These relationships create a "snap shot" view of all objects at any given time[12] and ensures that temporally consistent planning regions, transportation systems, and system components are presented to the planner. That is, only those objects which "exist" at the time specified will be revealed.

Summary

This transportation planning analysis highlights the need to implement four interdependent perspectives of transportation objects — functional, physical, spatial, and temporal. That is, Systems and their associated infrastructures provide many general and specialized transportation services to customer sites. The demand for and the performance of these services change over time. In order to be truly useful, digital objects must have the ability to mimic their world counterparts in form, function, and experience.

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[11] An event is significant to an object if it is "experienced" by the object. That is, if the experience alters one or more attributes of the object.

[12] A snap shot view contains all objects whose states co-exist.

FITS Class Index

FITS Class Descriptions

agency
Any organization of legal standing with regulatory or fiscal interest in transportation, including federal agencies, states, local units of government, Metropolitan Planning Organizations, private transit operators, and Indian tribal governments. This class may be specialized, if necessary.

air quality area
A geographic area that does not (or previously did not) achieve one or more federal national ambient air quality standards.

air quality hotspot
A location with higher than ambient levels of a pollutant. Hot spots may be attributed to such things as weather patterns, topography and traffic intensity.

airport
A facility for transferring passengers or cargo onto and off of aircraft.

allocate travel demand event
An activity that allocates the total amount of person trips and commodity flows to each component of a transportation system.

anchor point
A known point or location along a transportation corridor such as an intersection, bridge, monument, post, travelway terminus, etc.

anchor section
The explicit domain of valid linear locations. The direction of the section establishes the positive direction.

assemble trn sys event
An activity that assembles functionally related transportation components into a transportation system.

assembly
An assembly is a link class responsible for maintaining the assembly states of components and their respective containers.

bikeway
Any road, street, path or way that is specifically designated in some manner as being open to bicycle travel.

bikeway system
An ordered set of bikeways.

border crossing
An international port of entry primarily between the U.S. and Canada or Mexico.

bridge
A structure, including supports, erected over a depression or an obstruction such as water, highway or railway, and having a track or passageway for carrying traffic or other moving loads and having an opening measured along the center of the roadway of more than 20 feet between the undercopings of abutments or springlines or arches or extreme ends of openings of multiple boxes; may include multiple pipes where the clear distance between openings is less than half the smaller contiguous opening. AASHTO.

bridge element
A component of a bridge. See PONTIS data dictionary for a list of bridge elements.

bridge element condition
The condition and extent of the operational or physical characteristics of a bridge elements. See PONTIS for an example of bridge element condition ratings.

bridge element experience
An experience that alters the state of a bridge element.

bridge experience
An experience that changes the state of a bridge.

bridge inspection
A critical examination of a bridge conducted to improve knowledge about its state.

bridge system
An ordered set of bridges

bridge treatment
Any action that alters the state of a bridge

busway
An exclusive rights-of-way or fixed guideway reserved for buses.

component system
A transportation system composed of transportation elements.

continuous flow facility
Any facility such as pipelines used for the transport of materials.

continuous flow system
An ordered set of continuous flow components.

crash
An incident involving at least one motor vehicle resulting in personal injury or property damage.

culvert
Any structure under a travelway having a clear opening of twenty feet or less as measured along the center of the travelway.

customer site
A person trip or commodity flow generator; a trip origin or destination. Customer sites include specific trip generators such as major employers or aggregate sites such as travel analysis zones.

depot
A rail, bus, truck or marine terminal.

depot facility
The buildings, parking lots and other improvements associated with a depot.

determine bridge state event
An activity that determines the state

determine pavement state event
An activity that determine pavement states.

determine roadway state event
An activity that determines the state of a roadway.

determine safety state event
An activity that determines the state of a safety section or hazardous site.

determine traffic state event
An activity that determines the state of a traffic section

determine travel demand event
An activity that determines the total anticipated person trips, commodity flows and characteristics for a transportation system.

determine trn cmpnt function event
An activity that determines which transportation components can be used to support a specific transportation system function.

determine trn sys event
An activity that determines the function (*e.g.*, services) that characterizes the purpose of a transportation system.

event
An isolated instant in time. An event is said to occur at time *t* if it occurs at any time during the chronon represented by *t*.

experience
An event participated in. Significant experiences are those that change object states.

FITS event
An activity that is part of the Functionally Integrated Transportation Business System.

fixture
Any equipment or hardware associated with a transportation system. Examples include RR crossing safety hardware, lighting fixtures, beam guard, signs, manholes, catch basins.

fleet
The vehicles used in a public transportation system. "Fleet" refers to highway vehicles; "rolling stock" refers to rail vehicles.

flexible pavement
A pavement structure which maintains intimate contact with and distributes loads to the subgrade and depends upon aggregate interlock, particle friction and cohesion for stability.

freight distribution route
A specified route identified as significant in the transport of freight, which must be considered in the transportation planning process.

geographic object
A geographic object is an object representing a real or artificially defined phenomenon which has, or potentially has some kind of spatial or spatial temporal position. SAIF release 3.1, p. 49, April 1994.

geographic planning area
A set of spatial object that represent the location of a planning are at some cartographic scale and resolution.

geographic reference network
A set of spatial objects that represent the position of the reference network at some cartographic scale and resolution.

highway
A public way dedicated to the purposes of vehicular travel, including the entire area within the right of way. This area may contain more than one roadway.

highway interchange
A system of interconnected ramps between two or more traveled ways that are grade separated.

highway intersection
The general area where two or more highways join or cross. Highway intersections involving only two highway sections do not offer route choice and are used to represent significant change in highway section characteristics.

highway route
The official designation of a highway, street or road.

highway system
Any designated collection of highways. Examples include National Highway system, Federal Aid System, Interstate Highway System, Strategic Highway Network.

highway traffic counter
A site where continuous traffic monitoring operations occur.

historic site
A building, monument, park, cemetery or other site having public interest and national regional or local significance, which should be considered in the transportation planning process.

household
A domestic establishment including the members of a family and others living in the same dwelling. Households are the basic unit of travel behavior and trip generation.

intermodal system
An ordered set of transportation components from more than one mode or means of transportation.

junction
A site that allows a change in travel route only (not transportation mode). Junctions connect two or more transportation links of the same type.

linear references
The location of a site relative to a traversal in some system. A linear reference object is a container of linear locations represented by traversals and their reference point sites.

link demand
The number of trips that would probably made during a defined period of time by vehicles or passengers along a particular transport link under specified conditions.

maintenance facility
The buildings, parking lots and other improvements used for the upkeep of public transportation vehicles, machinery or equipment.

metropolitan planning area
The geographic area in which the metropolitan planning process must be carried out. See CFR 450.308

military installation
A military base, fort, armory, field, *etc.*

national park
A park operated by the U.S. Park Service.

network topology
Each instance represents a connection between two components. This relationship is used to define network structures. See SAIF release 3.1 p 124 connected_ to class for discussion.

node demand
The number of trips that would probably made during a defined period of time by vehicles or passengers through a transport node under specified conditions.

noise barrier
A structure designed to mitigate the impact of transportation related noise on surrounding areas.

objective
A statement of direction and extent for the availability, quality or performance of transportation. Source: PFS Phase A Data Dictionary.

pavement
A pavement course or layer, including base course and overlays.

pavement experience
An event that alters the state of a pavement section.

pavement inspection
A critical examination of a pavement conducted to improve knowledge about its state.

pavement structure
The combination of all pavement courses placed on a subgrade to support traffic load and distribute it to the roadbed. Used to monitor composite strength and deflection indicators.

pavement system
An ordered set of pavement structures.

pavement treatment
Any action that alters the state of a pavement.

pedestrian system
An ordered set of pedestrianways.

pedestrianway
A rights-of-way dedicated for the exclusive use of pedestrians. Includes people movers, skyways, sidewalks.

phenomenon
A significant occurrence or event. Used as the most general abstract superclass in the model. Every object is or represents, by definition, a phenomenon.

pipeline farm
A facility for transferring materials from pipelines or rail cars.

planning area
A territorial unit used in land use and transportation planning analysis.

planning corridor
A strip of land between two transport nodes within which traffic, topography, environment and other characteristics are evaluated. Corridors may be existing or proposed.

planning event
A unit of planning activity that, when complete, leaves the enterprise in a consistent state.

planning region
An entire planning area, usually either a metropolitan planning region or a statewide region.

planning scenario
A hypothesized chain of experiences.

planning workbench
The planning workbench is the mechanism for accessing — through a single, consistent interface — all of the objects defined by the transportation planning business systems architecture. See white paper dated 10/17/94.

POINTS event
An activity that is part of the Policy Integration Business System.

port
A facility for loading and off-loading passengers and cargo from ships.

public transportation asset
Any public transportation facility or equipment.

public transportation equipment
Unstationary public transportation assets.

public transportation system
A set of components that provides transportation service to the public using vehicles that transport more than one person for compensation. Subclasses may include public transit and paratransit systems.

rail system
An ordered set of rail components. *e.g.*, a railroad.

railroad crossing
At grade intersection of a railway and a highway.

railway
A dedicated rights-of-way reserved for train travel. Includes light rail, heavy rail, rapid rail, commuter rail.

recreation area
A significant scenic or recreational travel destination.

reference network
A frame of reference, or datum, used to control linear locations. The reference network is used for both field locations and data base representations of those locations.

reference post
A numbered post placed along a travelway. The number may represent a milepoint or may be arbitrary.

retaining wall
A structure used to retain soil.

rigid pavement
A pavement structure which distributes loads to the subgrade having as one course a portland cement concrete slab of relatively high bending resistance.

roadway
The portion of a highway designed or built for vehicular use. Includes the traveled way, shoulders, gutters and auxiliary lanes.

roadway experience
An event that affects the state of a roadway.

roadway system
An ordered set of roadway sections.

roadway treatment
An action that alters the state of a roadway. Actions include construction, maintenance and rehabilitation.

safety hotspot
A location with greater than expected numbers of crashes. A hazardous location.

safety section
A location established to monitor crash incidents and establish crash rates.

safety section experience
An event that alters the state of a safety section.

safety system
An ordered set of safety sections.

section
A linear portion of a transportation system or its components defined as the portion of the component located between two sites.

site
A transportation component that exists or occurs at a specific place.

state
A condition of being defined by constant attributes and link relationships. A state can be thought of as a portion of time between events. A State with no end state is current in when valid time equals system time.

statewide planning area
A territorial unit comprising one of the 50 United States, Puerto Rice, or the District of Columbia.

street address
A geographic location of a building.

structure
An engineered works such as bridge, noise barrier, box culvert.

system demand
The actual or latent demand for persons of commodity movement on a transportation system.

temporal topology
See discussion in SAIF release 3.1 p. 118 ff.

terminal
A facility allowing intermodal transfer of passengers or goods.

traffic experience
An event that alters the state of a traffic section.

traffic record
The results of a traffic census.

traffic section
A statistical section used to monitor traffic statistics.

traffic system
An ordered set of traffic sections.

trail
A marked or established path used by pedestrians, bicycles or horses, especially through forests or other recreational areas.

trail system
An ordered set of trails.

TRAMMS event
An activity that is part of the Transportation Modeling and Monitoring Business System.

transit route
A designated, specified path to which a transit vehicle is assigned.

transit stop
An area where passengers wait for, board, alight and transfer between transit units. It is indicated by distinctive signs or pavement and curb markings.

transport link
A transport link is and historical, existing or anticipated travelway used to transport passengers or goods. The direction of the links establishes the primary direction in which the traversal is said to "run."

transport link experience
An event that alters the state of a transport link section.

transport node
A transport node is a place where travel originates (or ends) or a facility allowing for a change in transportation mode or travel route.

transport node experience
An event that alters the state of a transport node.

transport system
A transport system is an ordered collection of transportation components serving a transportation function in support of transportation objectives(*i.e.*, a FITS). These systems can be single mode (e.g., highway systems), multimodal (e.g., public transportation buses + light rail) or intermodal (e.g., freight or passenger based). The default transport system consists of all transportation choices within a predetermined region.

transport system link
An object responsible for maintaining the assemblies of transport systems and their links.

transport system node
An object responsible for maintaining the assemblies of transport systems and their nodes

transportation attachment
A site of interest or facility associated with a transportation system that is not an element of a system.

transportation complex
A collection of interconnected transportation components. Complexes are used to manage groups of components *i.e.* act as "containers." They are the primary mechanism for determining multicomponent performance. *e.g.*, pavement sections may collaborate with the traffic section complex

transportation component
An object regarded as part of a transportation system.

transportation element
Any transportation related object that affects or monitors the availability, quality or performance of transportation functions or services.

transportation system
An ordered set of transportation components.

transportation system experience
An experience that alters the state of a transportation system.

travel analysis zone
A division of a study area used for travel demand analysis purposes. A planning region is divided into zones, the number and size of which depend on land uses in the area, transportation access, census boundaries and political boundaries. Zone boundaries are defined so that land uses and activities are homogeneous, to the extent practicable. Travel analysis zones may be coincident with census blocks.

travel demand
The actual or latent movement of people or freight between two points for a specific purpose. Each trip (or aggregation of trips is characterized by mode choice.

traversal
The geographical route, path or course designated for travel or followed by a vehicle or traveler. Traversals also may be Names of designated paths through a transportation system. Examples include mainline routes, business routes, spurs, county routes, scenic, hazmat.

traversal link
An object responsible for maintaining the history of traversal and link assemblies.

traversal reference point
A point on a traversal that can be easily identified and whose identity and location are known.

TREADS event
An activity that is part of the Treatment Development Business System.

trn service center
The area and service used to enhance, regulate or respond to transportation. Examples include traffic control centers, police and other dispatch centers, weigh in motion sites, toll plazas, tourist rest areas.

tunnel
An enclosed passageway through or under an obstruction such as a city, river, mountain, or harbor.

water transport system
An ordered set of marine transport components.

waterway
A navigable water course, including canals, used for the transport of people or goods.

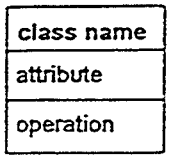
Object Model Notation

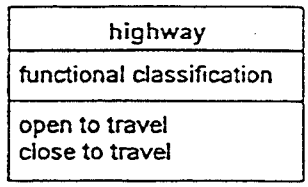
Basic Concepts

Notation

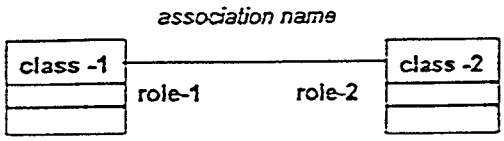
Example

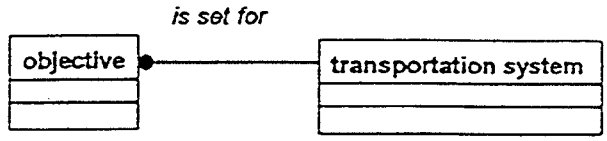
'ass: a group of objects with similar properties



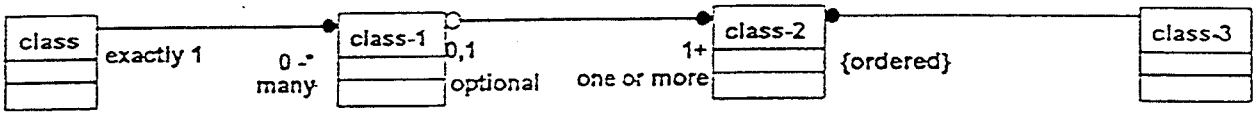


Association: a collaborative relationship between two or more classes

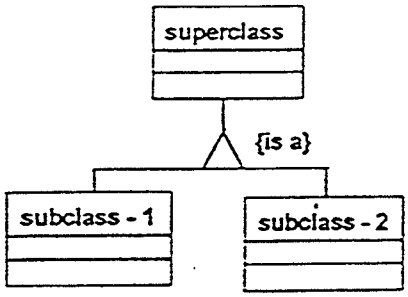


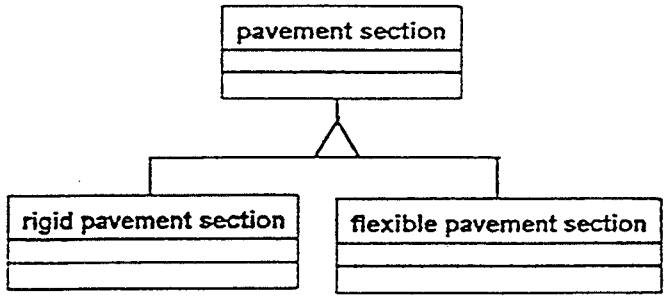


Multiplicity: the number of instances of one class that may relate to a single instance of another class

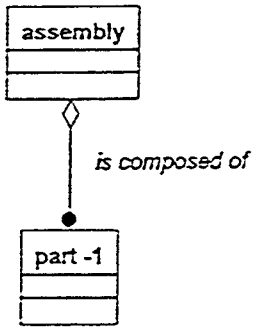


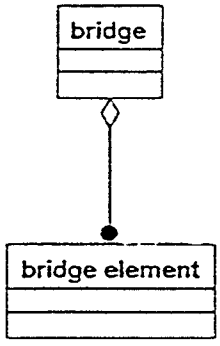
Generalization (inheritance): an association showing a succesive refinement of classes





Aggregation: a composite assembly containing component parts



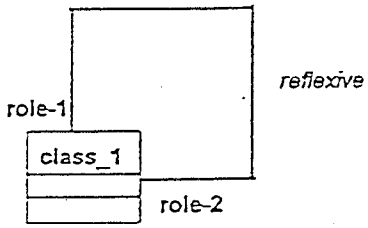


Object Model Notation
Advanced Concepts

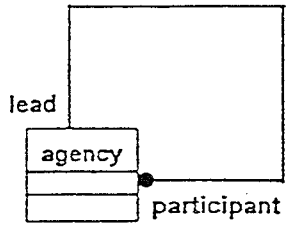
Notation

Example

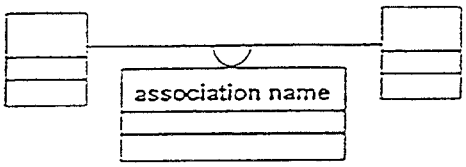
Reflexive association: an association involving only one class



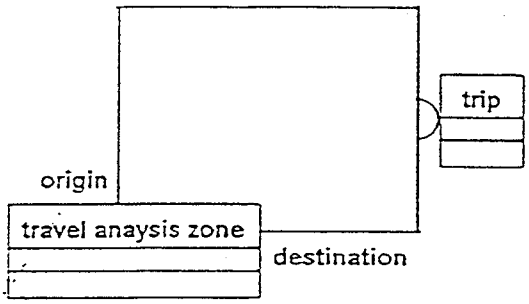
coordinates with



Association as class: a link with its own attributes, operations or associations

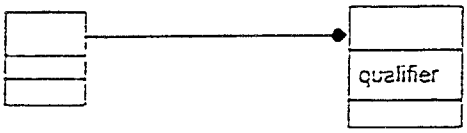


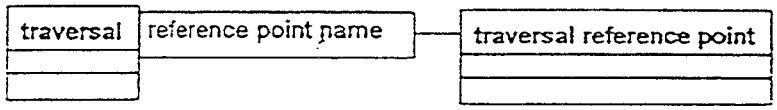
initiates trips between



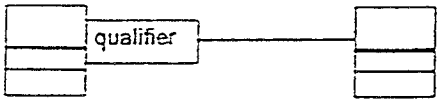
Qualified association: an association between two classes and a qualifier that reduces the effective multiplicity of the associati

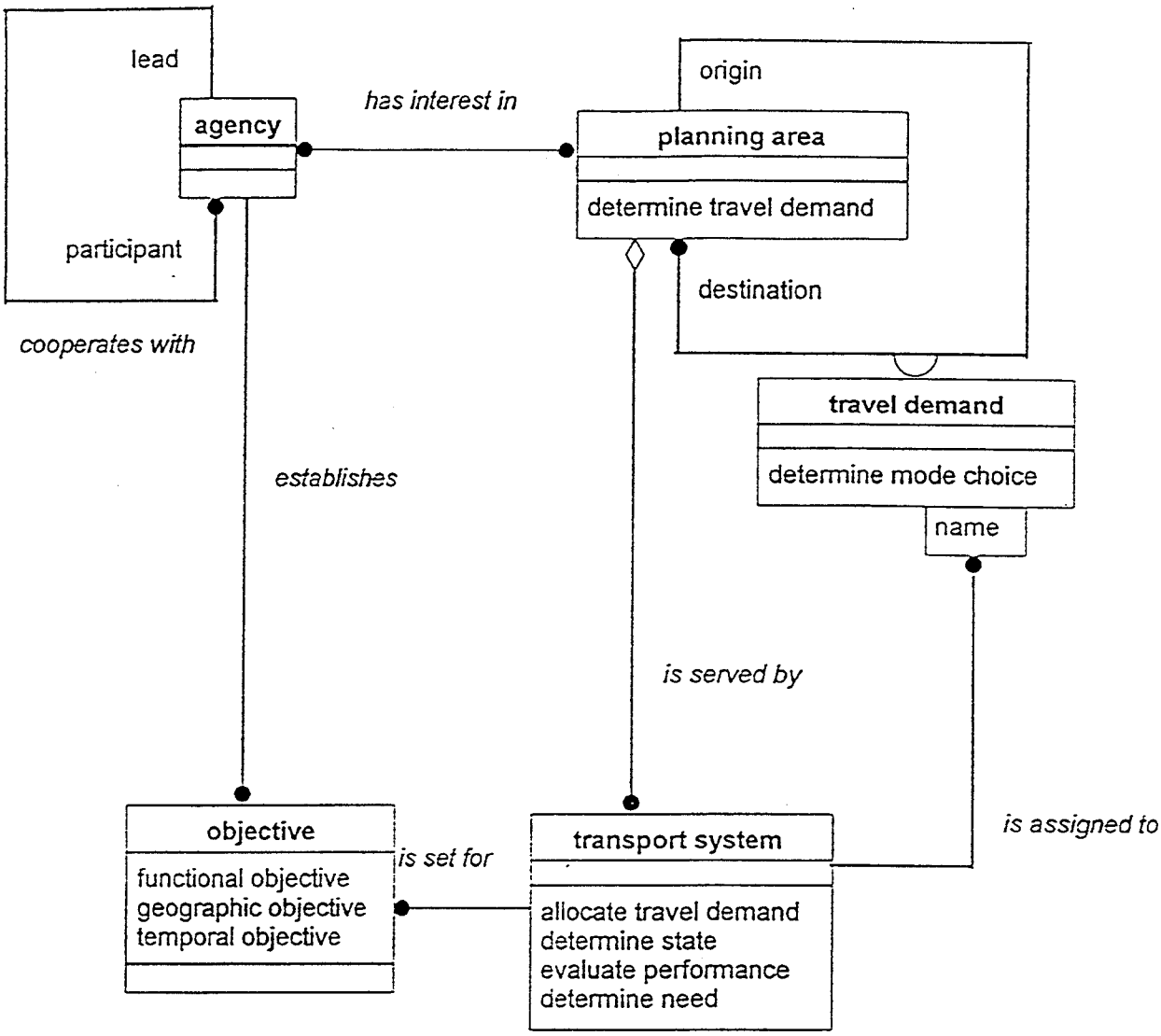
unqualified

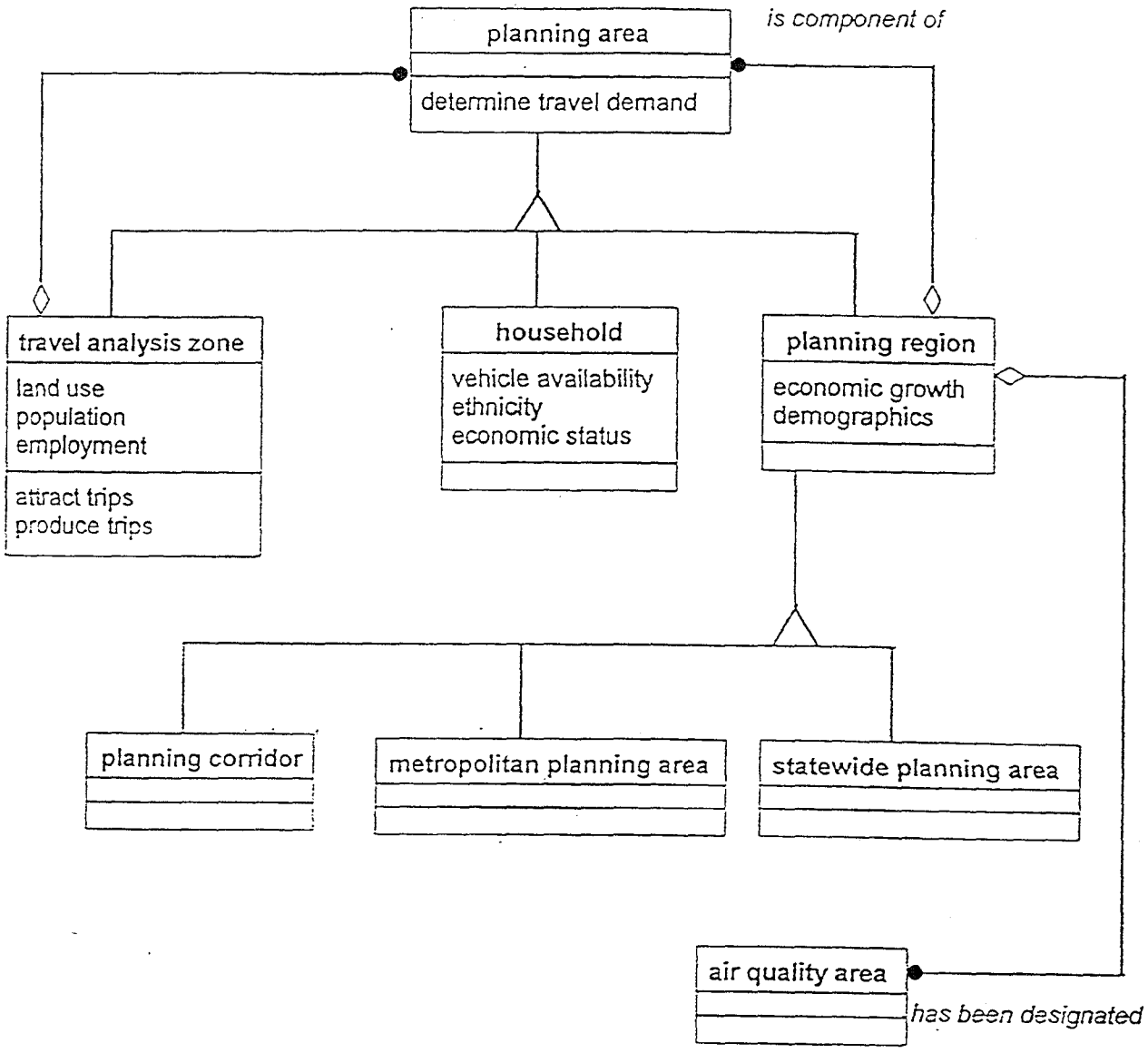


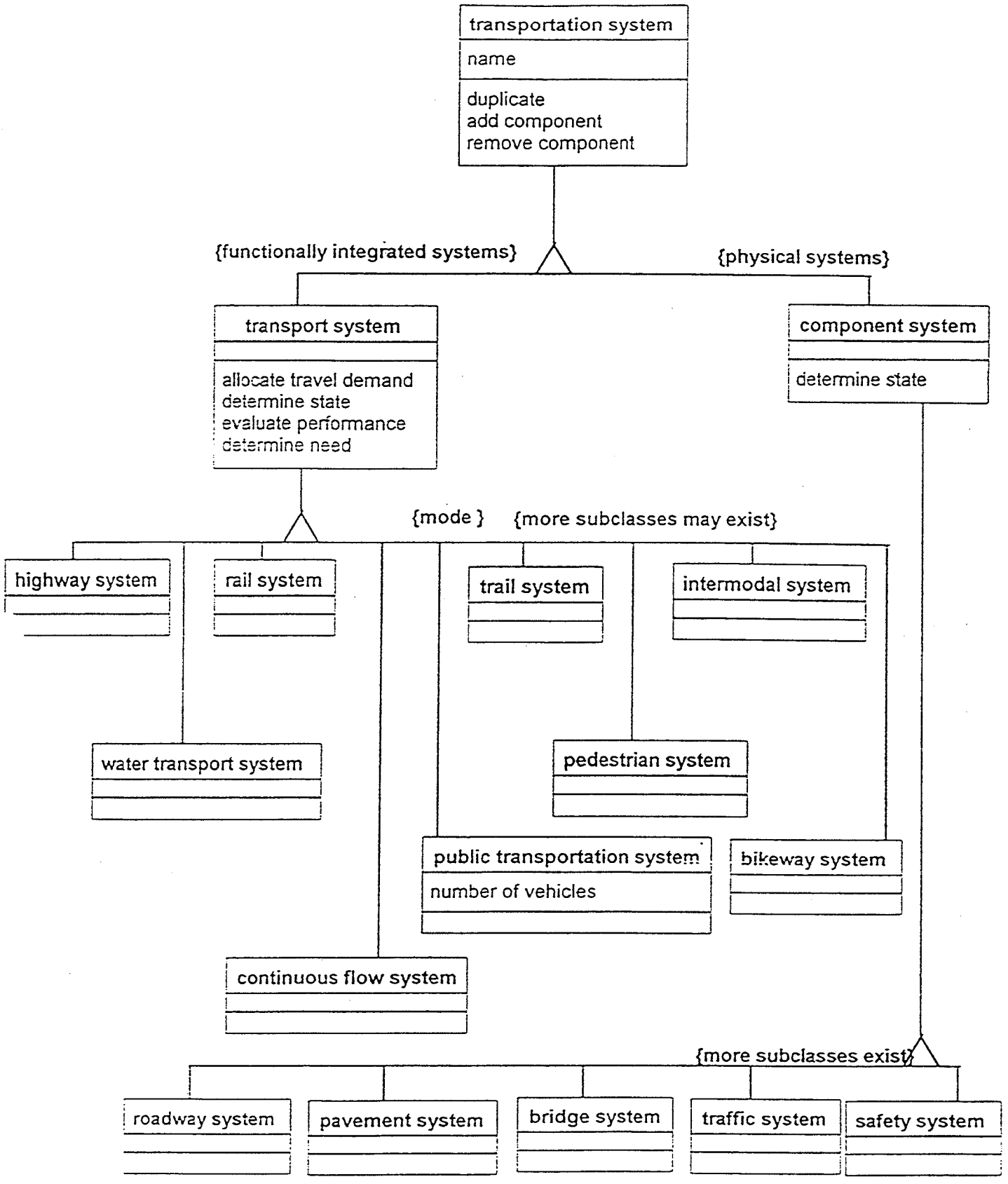


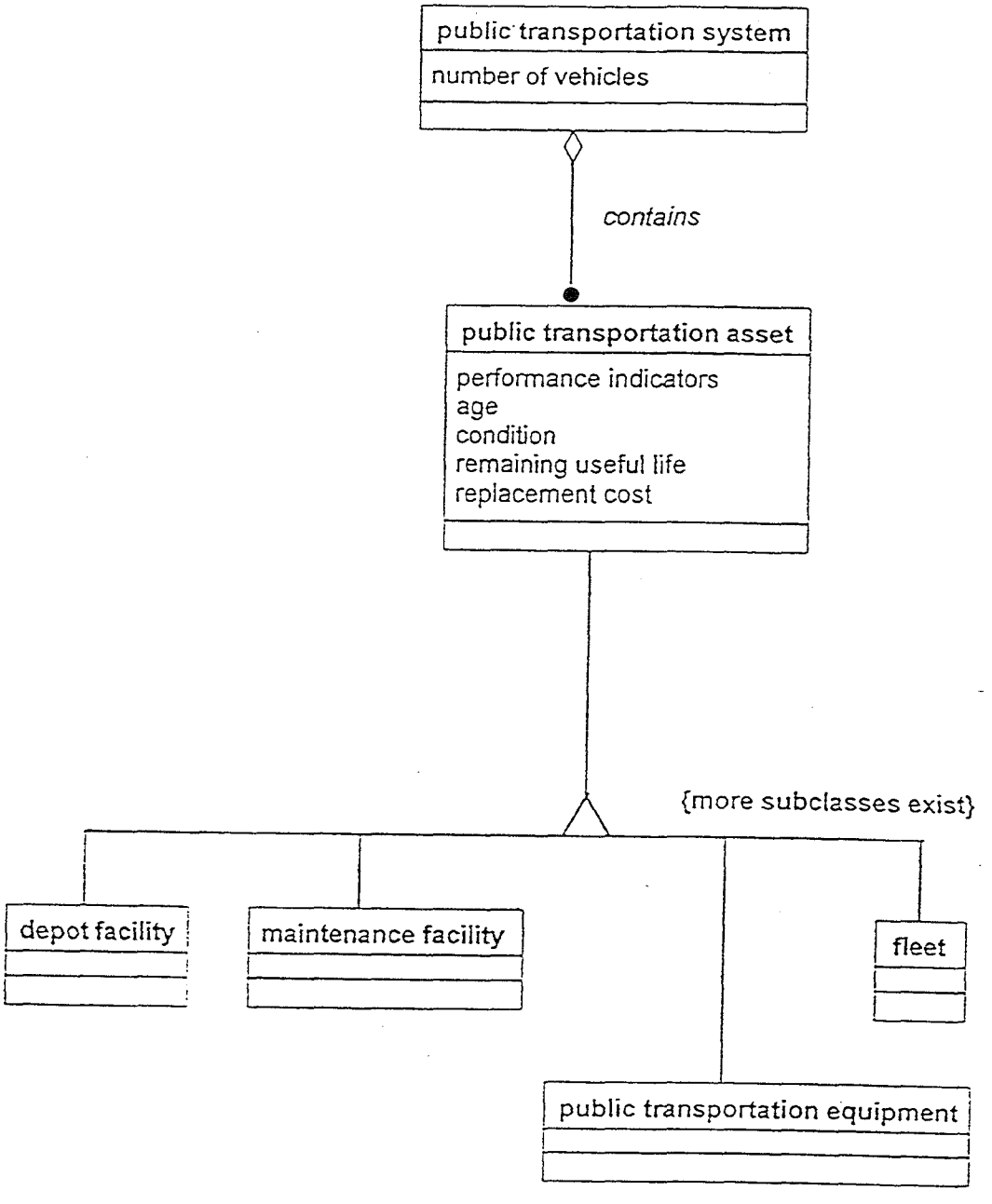
qualified

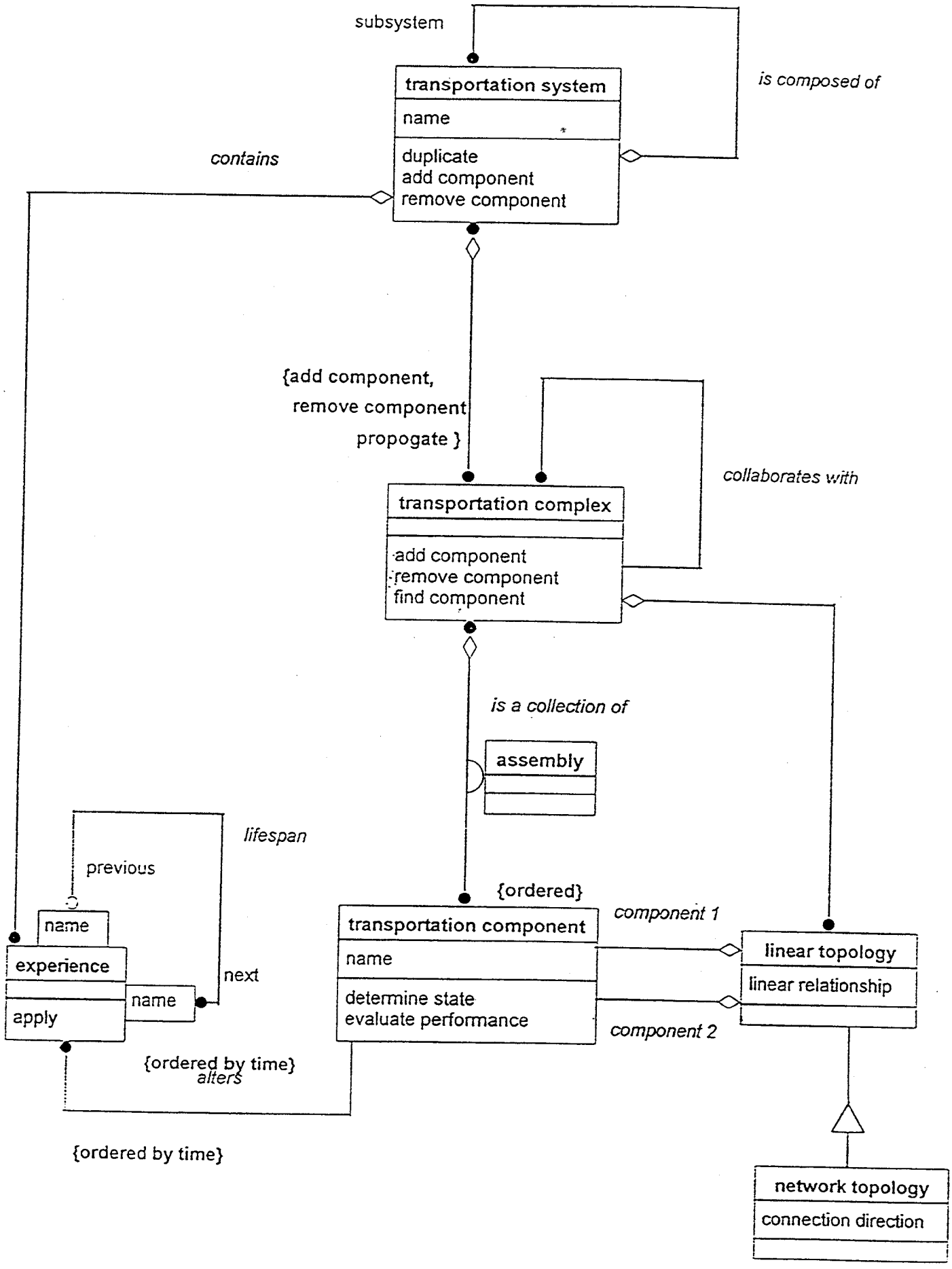


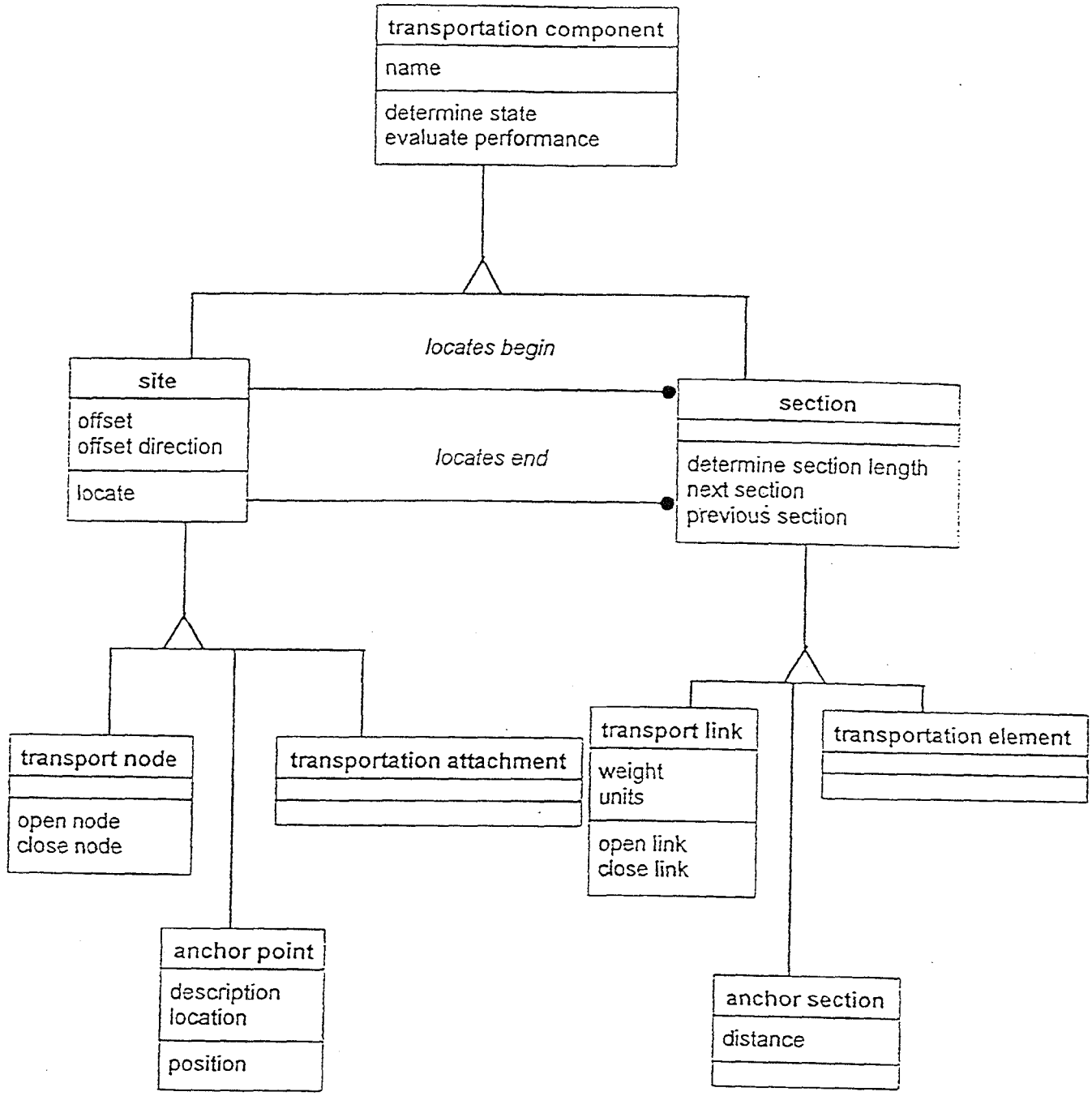

lead
agency
participant
cooperates with
has interest in
origin
planning area
determine travel demand
destination
travel demand
determine mode choice
name
establishes
is served by
is assigned to
objective
functional objective
geographic objective
temporal objective
is set for
transport system
allocate travel demand
determine state
evaluate performance
determine need

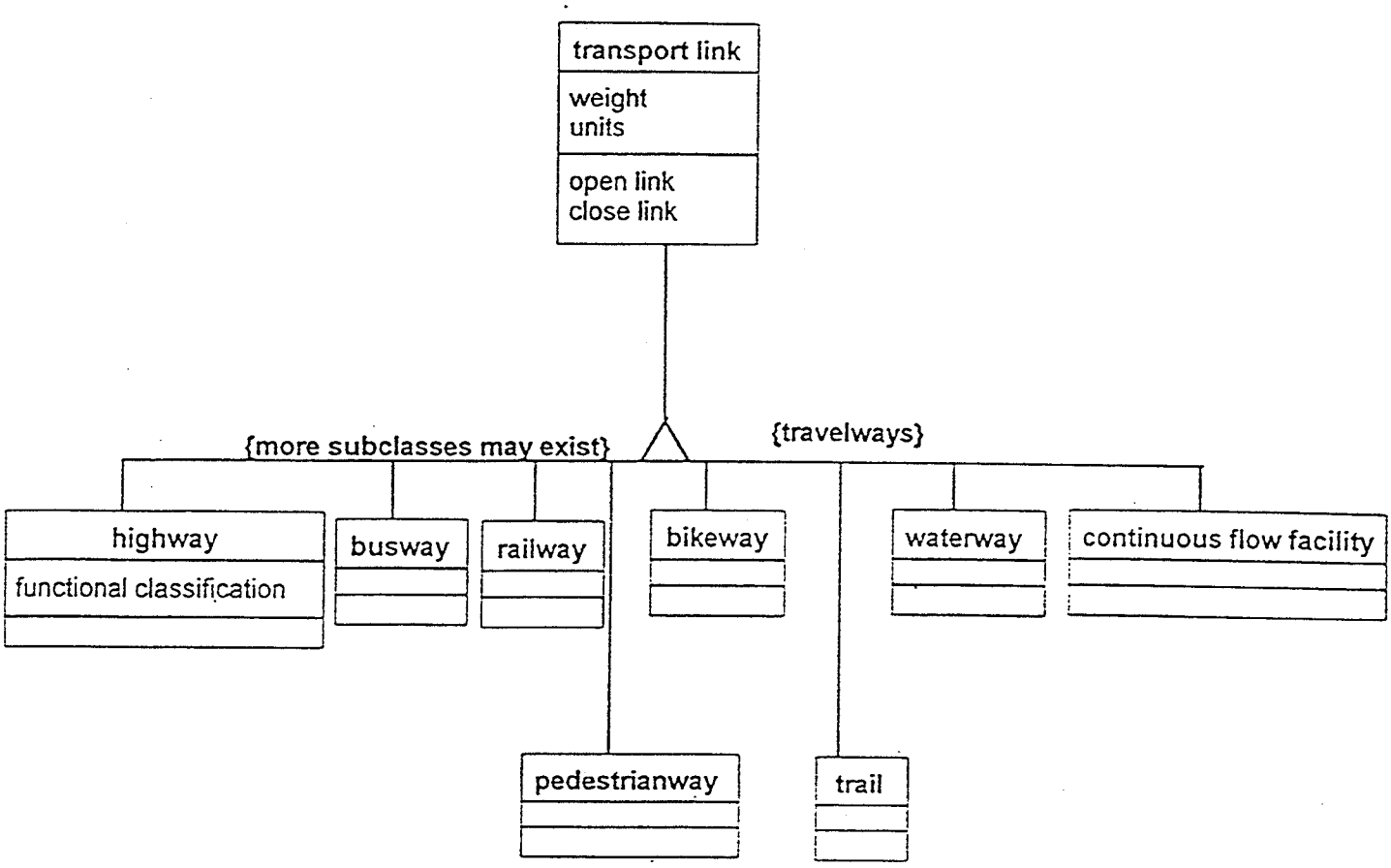

planning area
is component of
determine travel demand
travel analysis zone
land use
population
employment
attract trips
produce trips
household
vehicle availability
ethnicity
economic status
planning region
economic growth
demographics
planning corridor
metropolitan planning area
statewide planning area
air quality area
has been designated

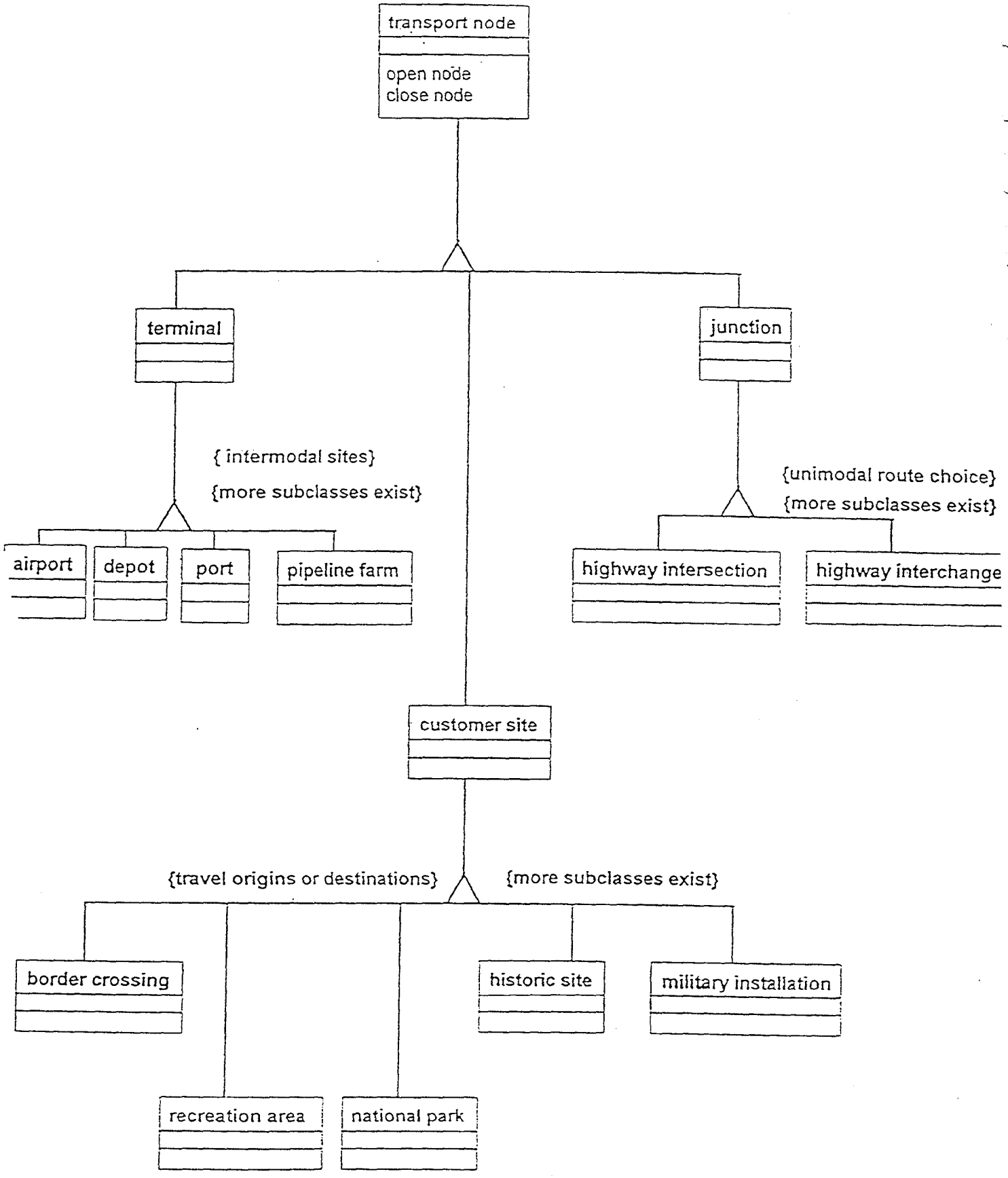

transportation system
name
duplicate
add component
remove component
{functionally integrated systems}
{physical systems}
transport system
allocate travel demand
determine state
evaluate performance
determine need
component system
determine state
{mode }
{more subclasses may exist}
highway system
rail system
trail system
intermodal system
water transport system
pedestrian system
public transportation system
number of vehicles
bikeway system
continuous flow system
{more subclasses exist}
roadway system
pavement system
bridge system
traffic system
safety system

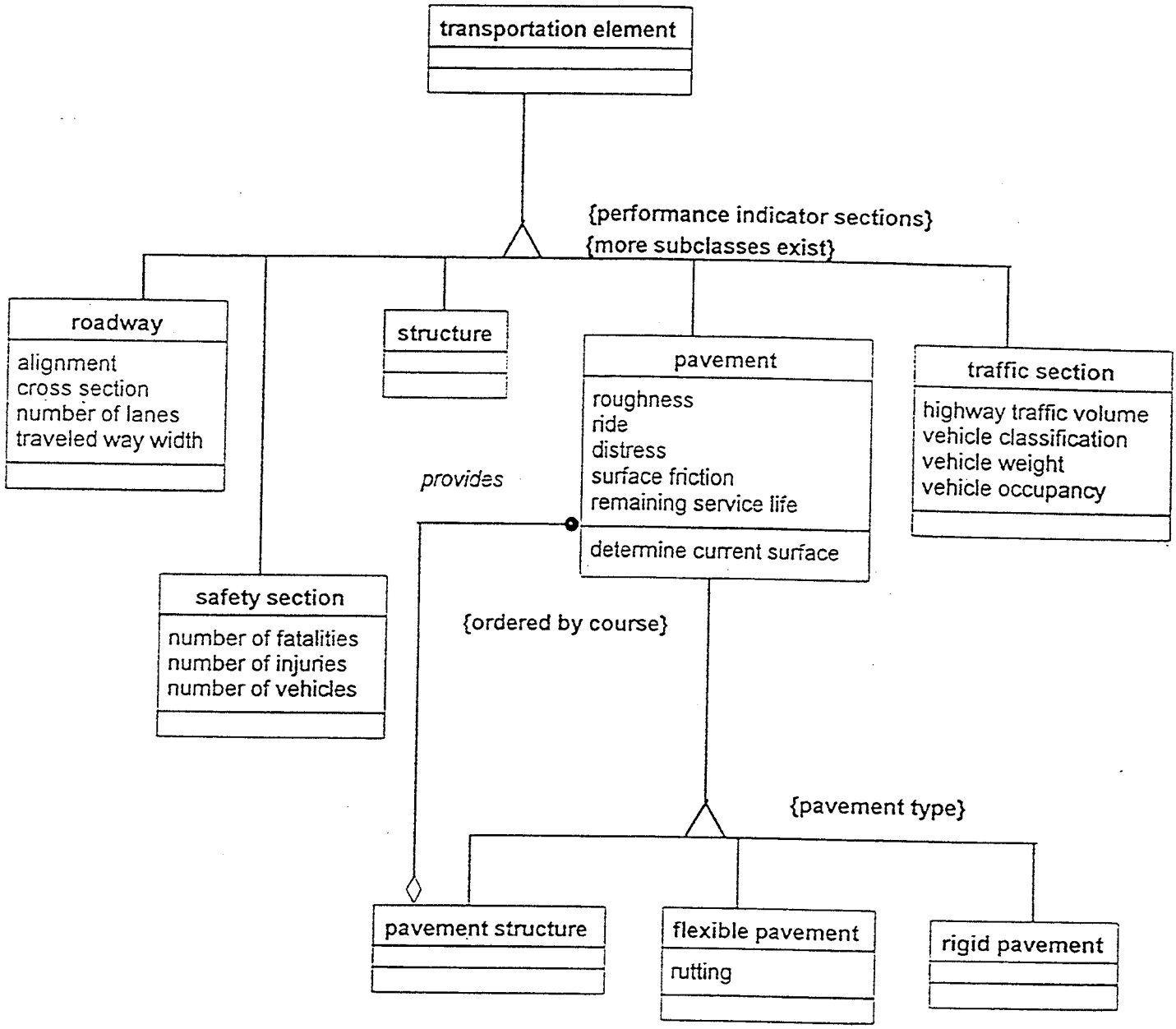

public transportation system
number of vehicles
contains
public transportation asset
performance indicators
age
condition
remaining useful life
replacement cost
{more subclasses exist}
depot facility
maintenance facility
fleet
public transportation equipment

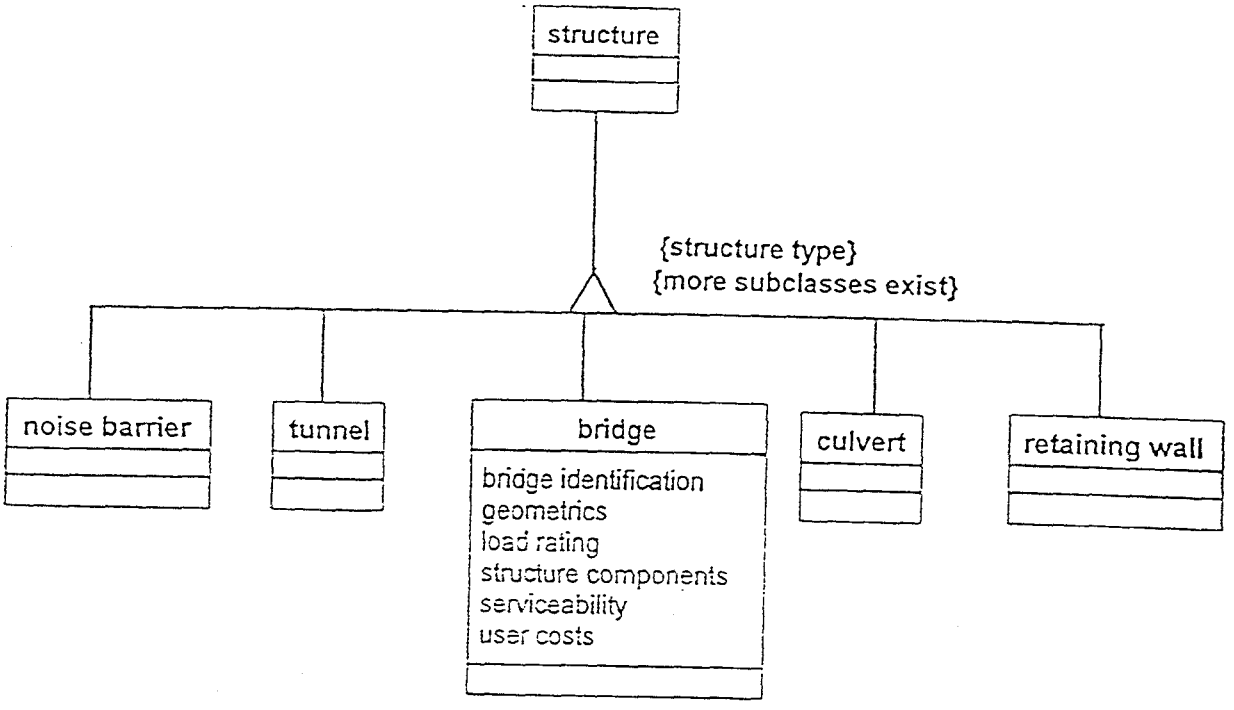

subsystem
transportation system
name
duplicate
add component
remove component
is composed of
contains
{add component,
remove component
propogate }
collaborates with
transportation complex
add component
remove component
find component
is a collection of
assembly
lifespan
previous
name
experience
apply
name
next
{ordered by time}
alters
{ordered by time}
{ordered}
transportation component
name
determine state
evaluate performance
component 1
component 2
linear topology
linear relationship
network topology
connection direction

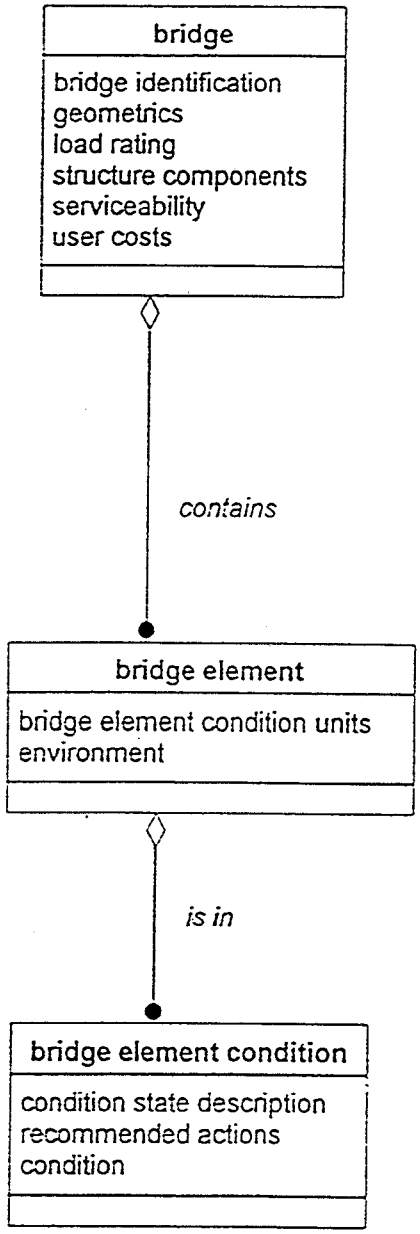

transportation component
name
determine state
evaluate performance
locates begin
locates end
site
offset
offset direction
locate
section
determine section length
next section
previous section
transport node
open node
close node
transportation attachment
transport link
weight
units
open link
close link
transportation element
anchor point
description
location
position
anchor section
distance

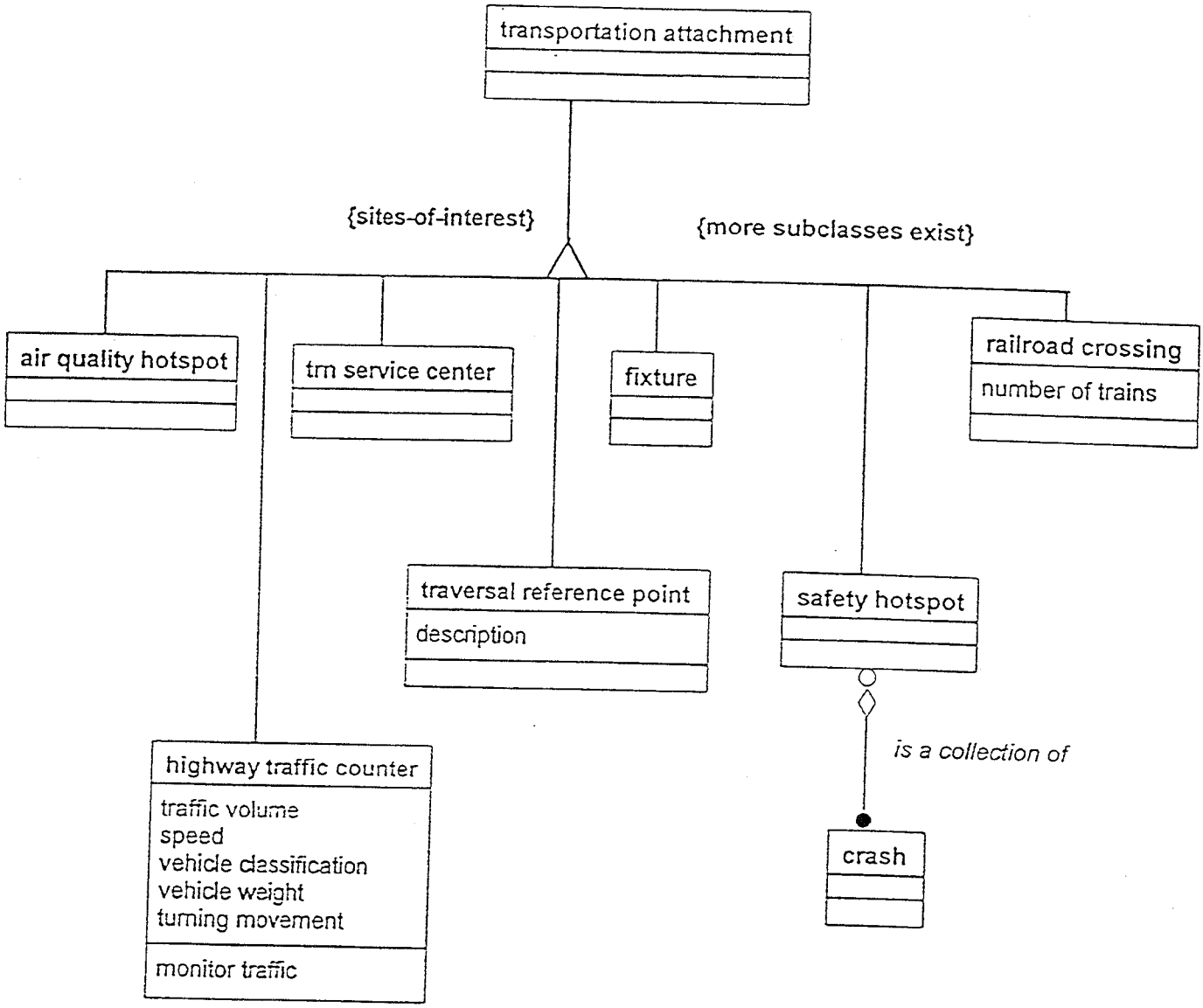

transport link
weight
units
open link
close link
{more subclasses may exist}
{travelways}
highway
functional classification
busway
railway
bikeway
waterway
continuous flow facility
pedestrianway
trail

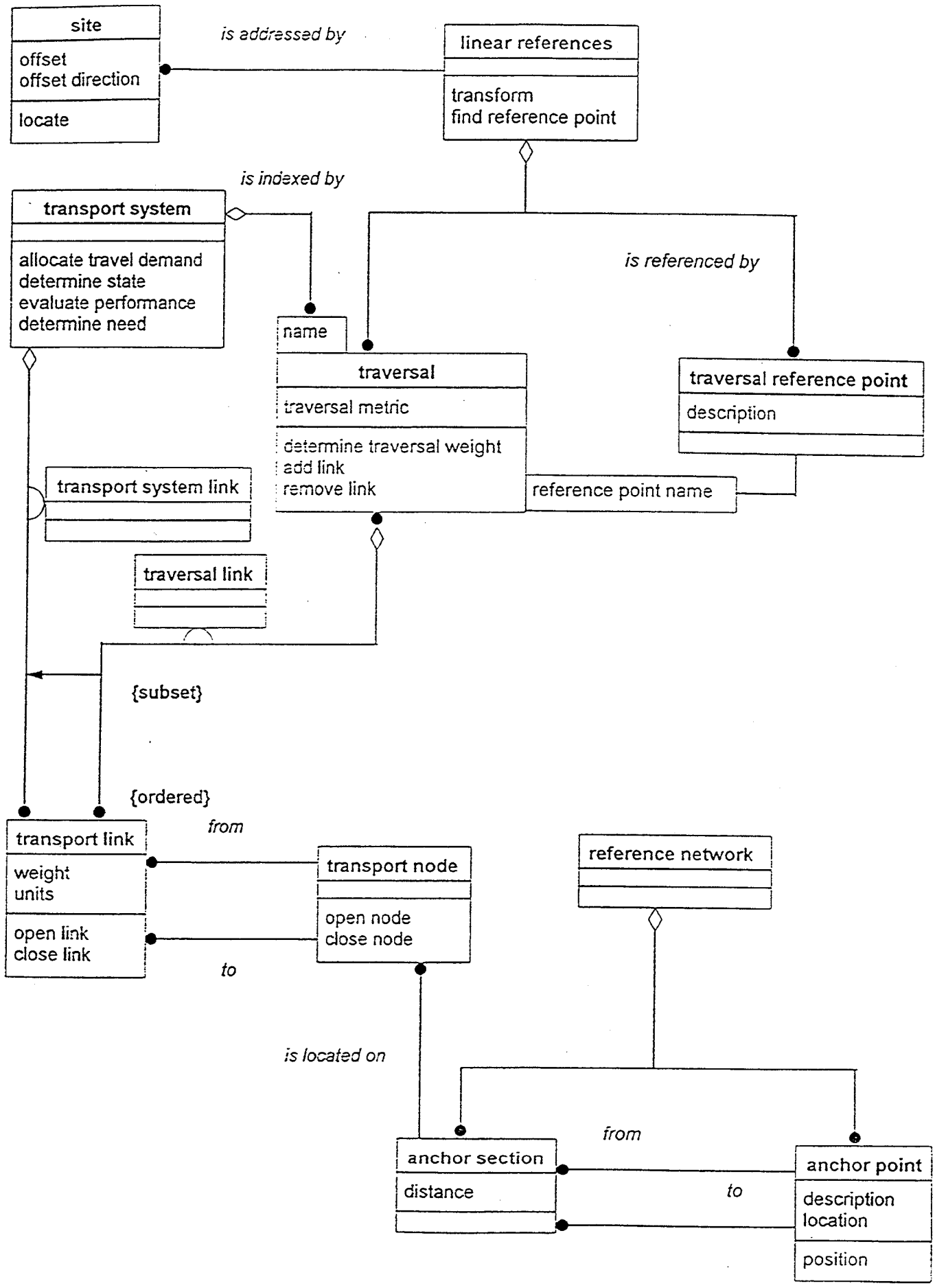

transport node
open node
close node
terminal
junction
{ intermodal sites}
{more subclasses exist}
{unimodal route choice}
{more subclasses exist}
airport
depot
port
pipeline farm
highway intersection
highway interchange
customer site
{travel origins or destinations}
{more subclasses exist}
border crossing
historic site
military installation
recreation area
national park

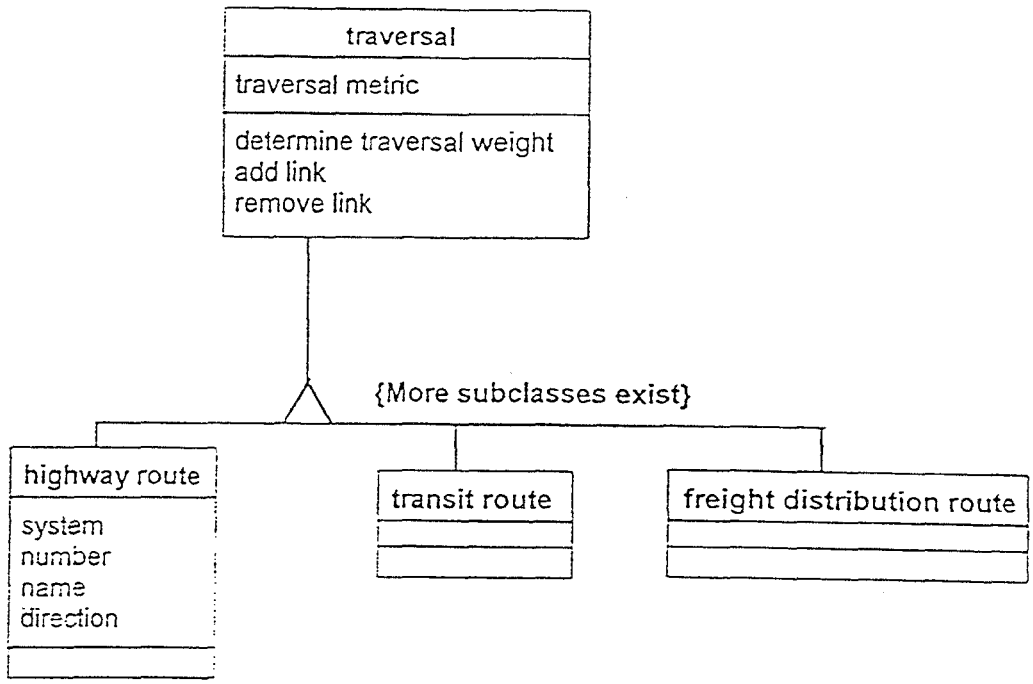

transportation element
{performance indicator sections}
{more subclasses exist}
roadway
alignment
cross section
number of lanes
traveled way width
structure
pavement
roughness
ride
distress
surface friction
remaining service life
determine current surface
traffic section
highway traffic volume
vehicle classification
vehicle weight
vehicle occupancy
provides
safety section
number of fatalities
number of injuries
number of vehicles
{ordered by course}
{pavement type}
pavement structure
flexible pavement
rutting
rigid pavement

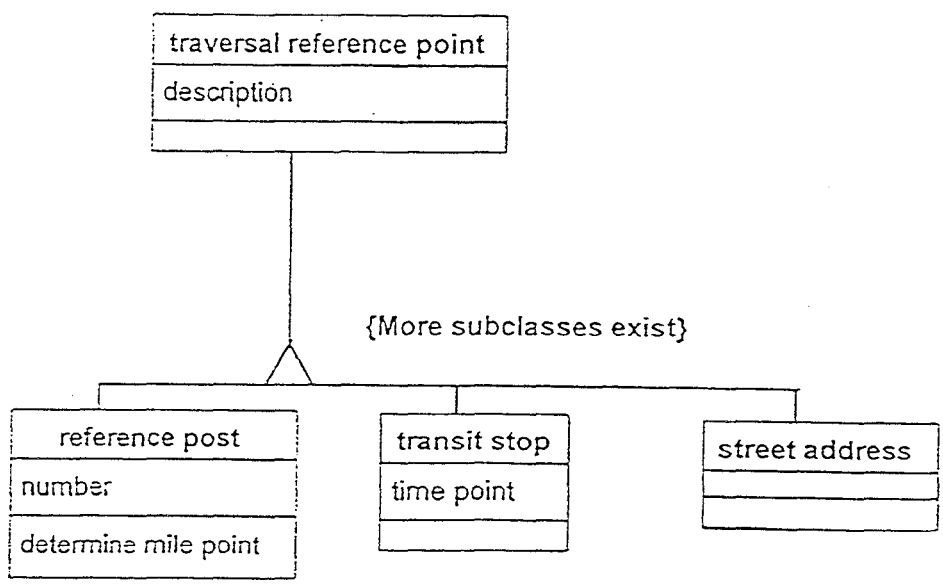

structure
{structure type}
{more subclasses exist}
noise barrier
tunnel
bridge
bridge identification
geometrics
load rating
structure components
serviceability
user costs
culvert
retaining wall

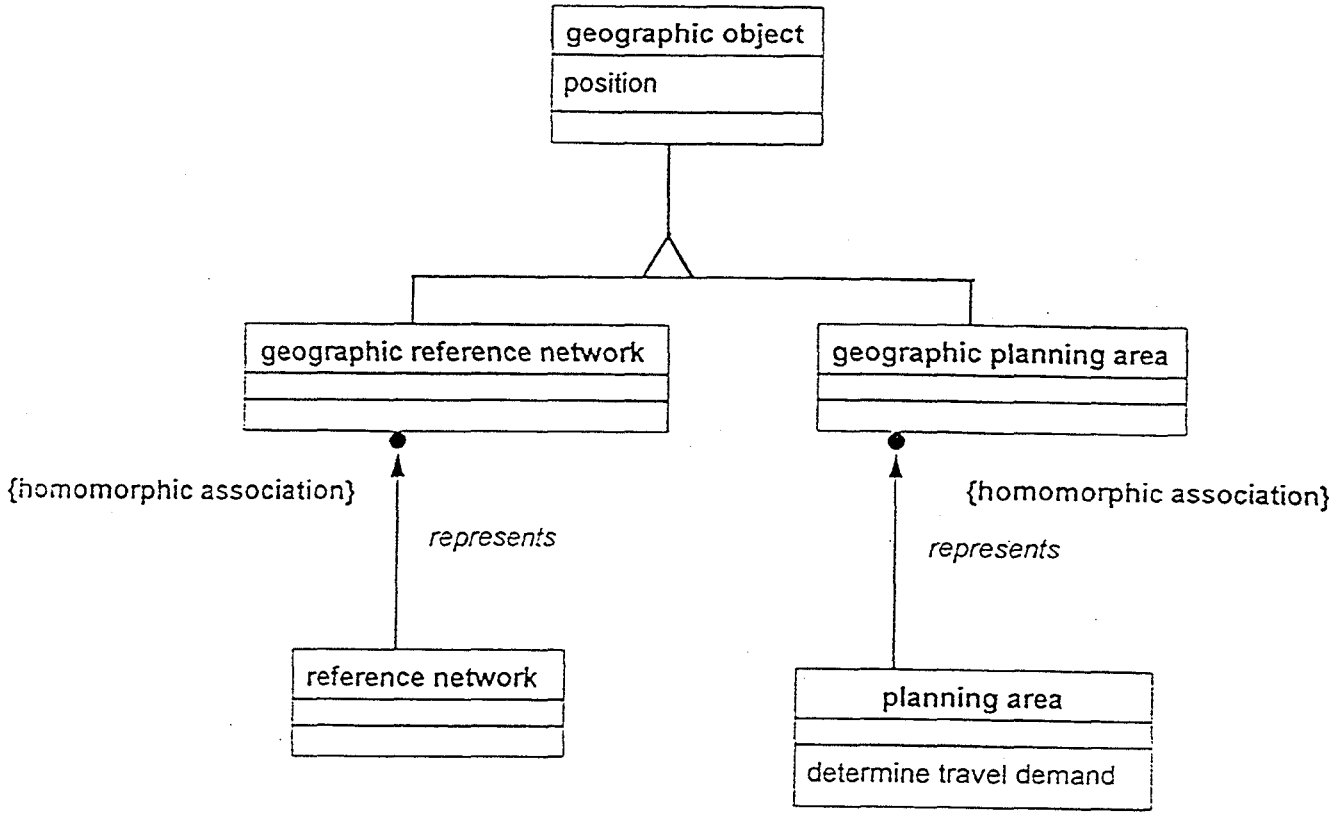

bridge
bridge identification
geometrics
load rating
structure components
serviceability
user costs
contains
bridge element
bridge element condition units
environment
is in
bridge element condition
condition state description
recommended actions
condition

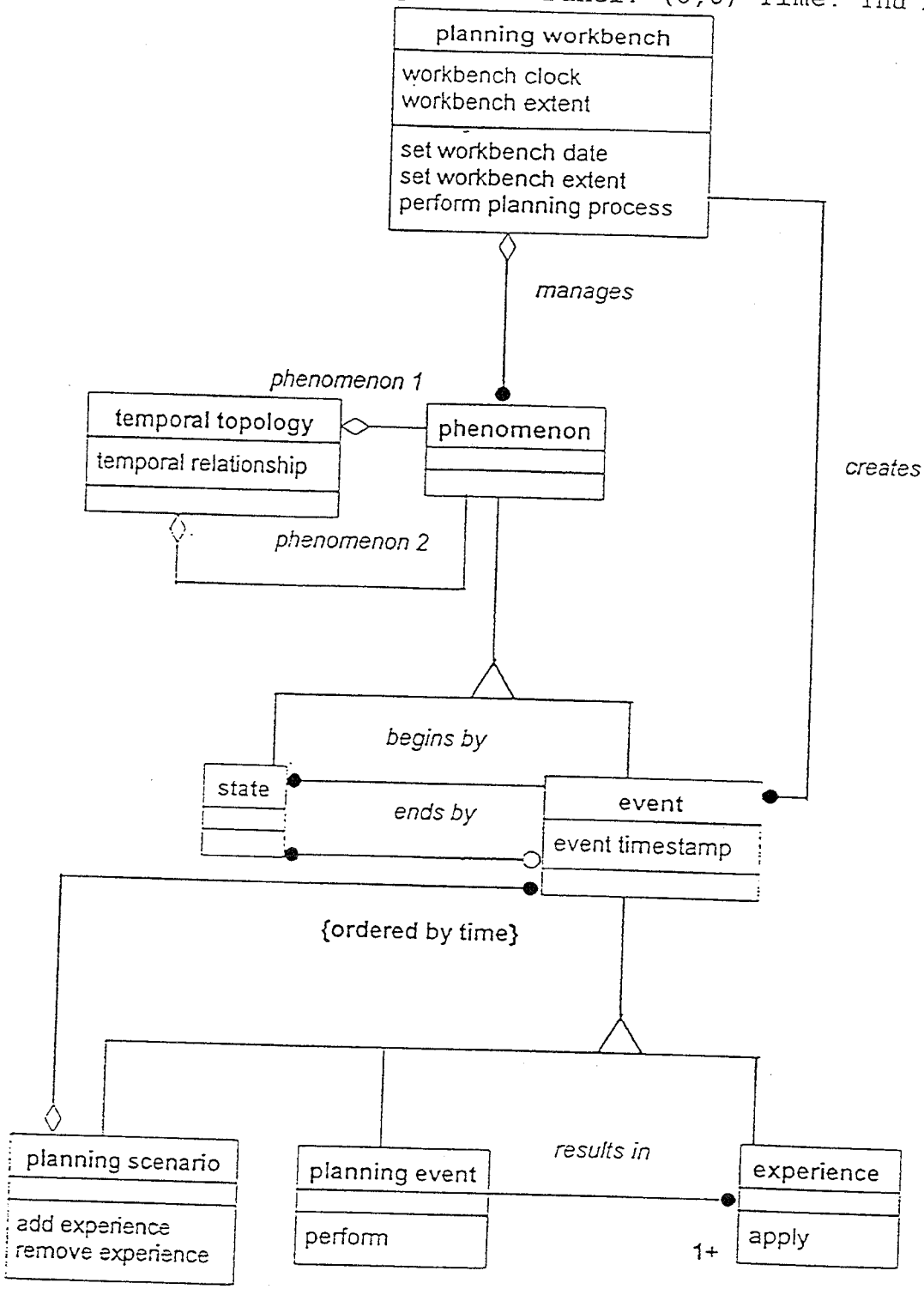

transportation attachment
{sites-of-interest}
{more subclasses exist}
air quality hotspot
tm service center
fixture
railroad crossing
number of trains
traversal reference point
description
safety hotspot
highway traffic counter
traffic volume
speed
vehicle classification
vehicle weight
turning movement
monitor traffic
is a collection of
crash

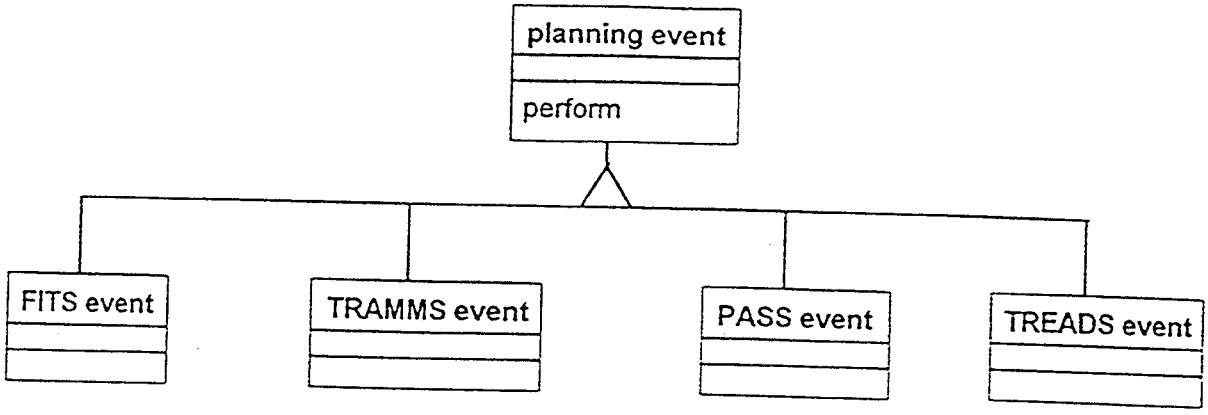

site
offset
offset direction
locate
is addressed by
linear references
transform
find reference point
is indexed by
transport system
allocate travel demand
determine state
evaluate performance
determine need
is referenced by
name
traversal
traversal metric
determine traversal weight
add link
remove link
traversal reference point
description
reference point name
transport system link
traversal link
{subset}
{ordered}
transport link
weight
units
open link
close link
from
to
transport node
open node
close node
reference network
is located on
from
to
anchor section
distance
anchor point
description
location
position

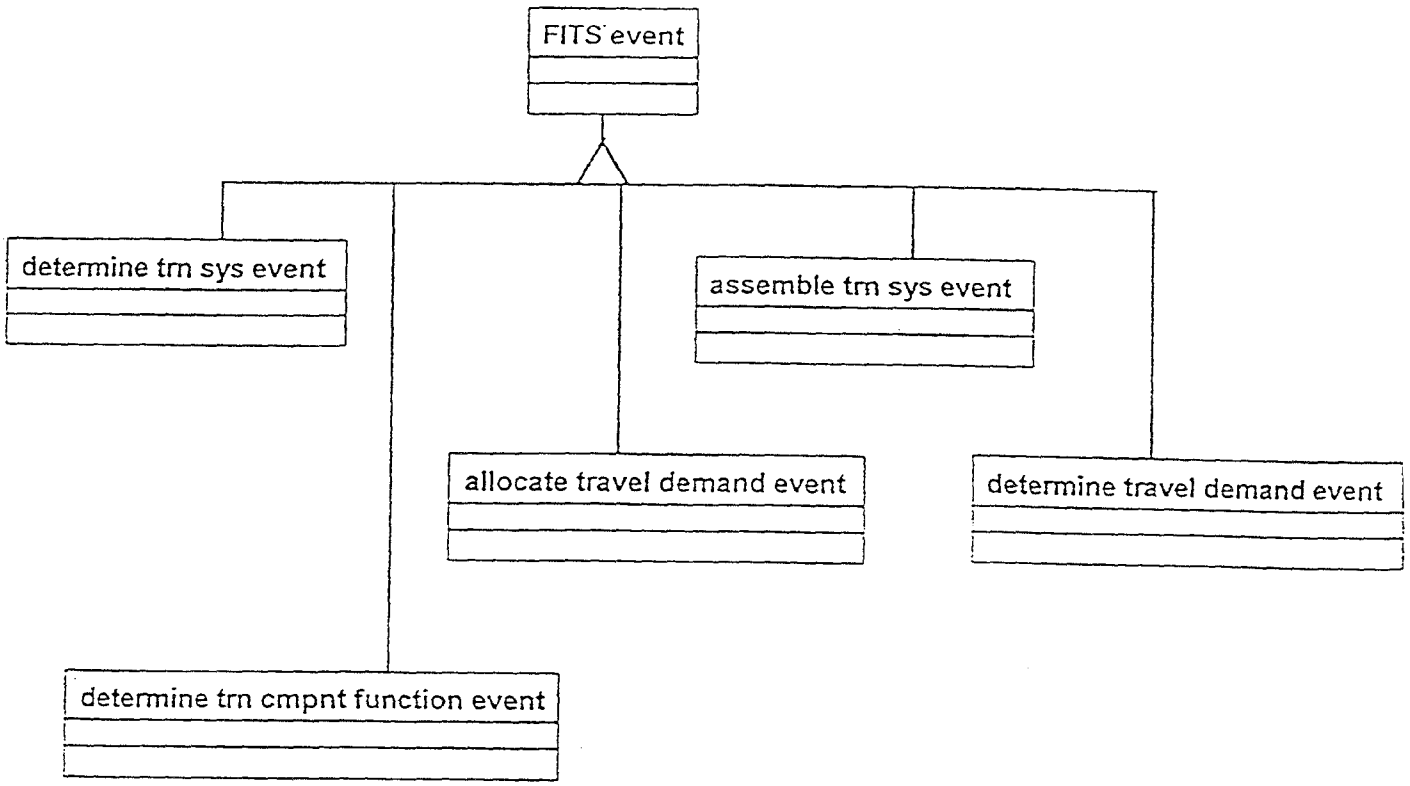

traversal
traversal metric
determine traversal weight
add link
remove link
{More subclasses exist}
highway route
system
number
name
direction
transit route
freight distribution route

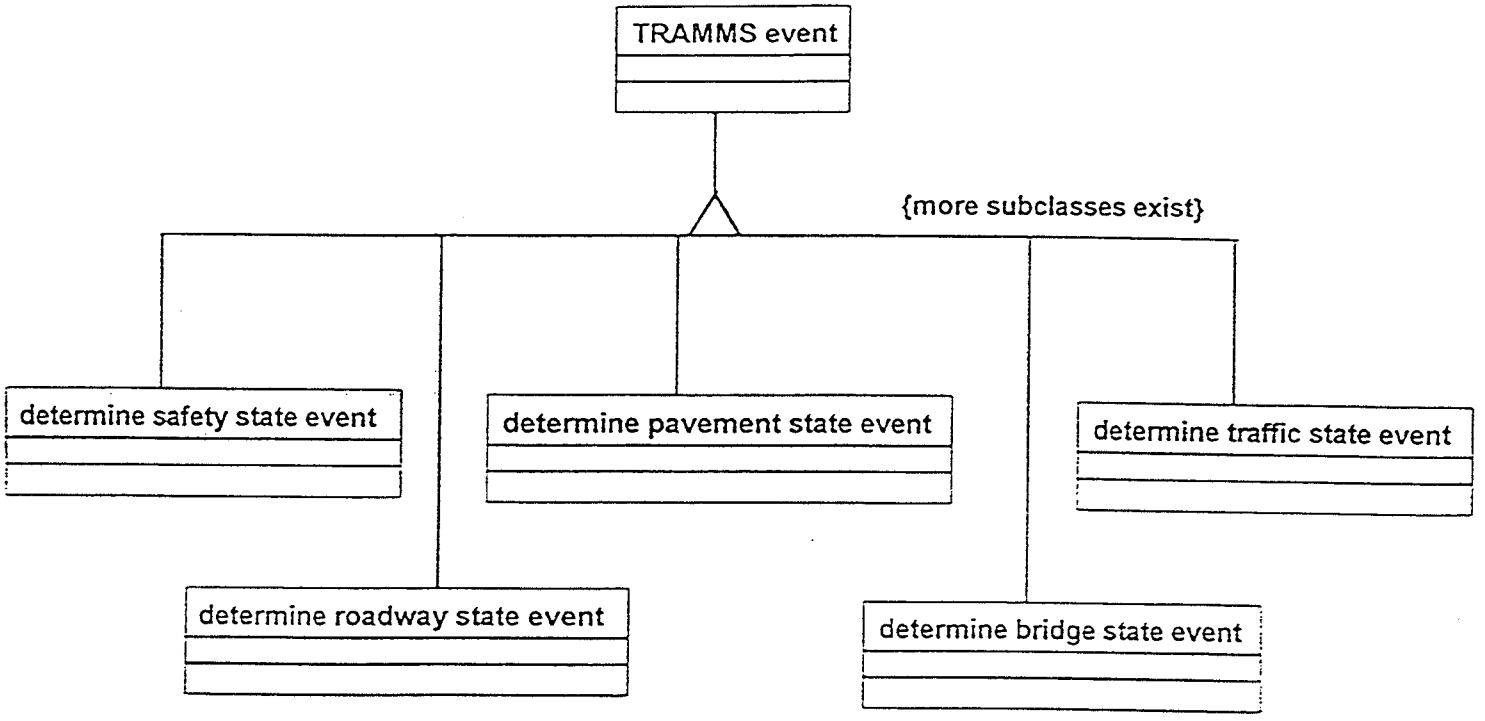

traversal reference point
description
{More subclasses exist}
reference post
number
determine mile point
transit stop
time point
street address

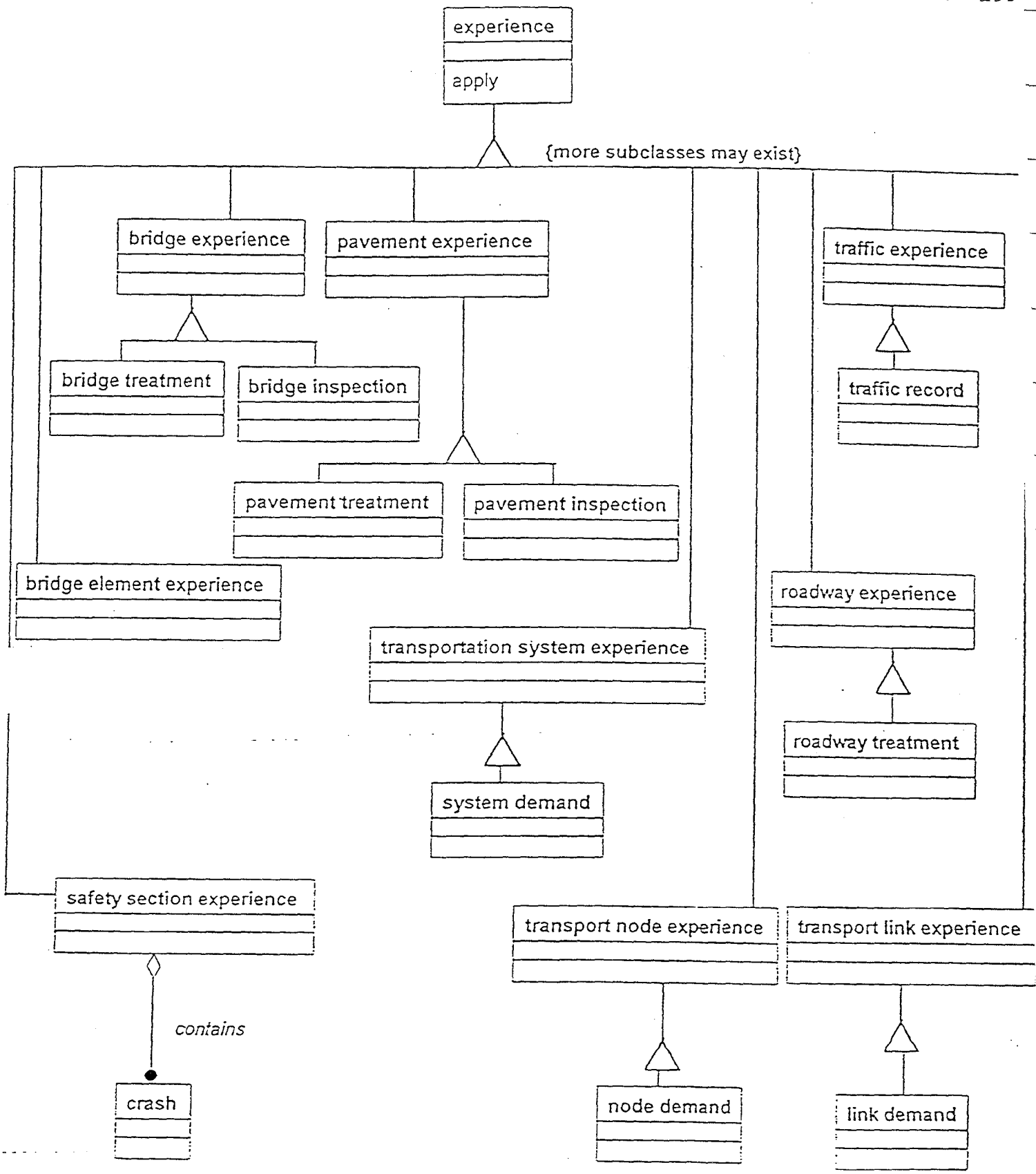

geographic object
position
geographic reference network
geographic planning area
{homomorphic association}
represents
{homomorphic association}
represents
reference network
planning area
determine travel demand

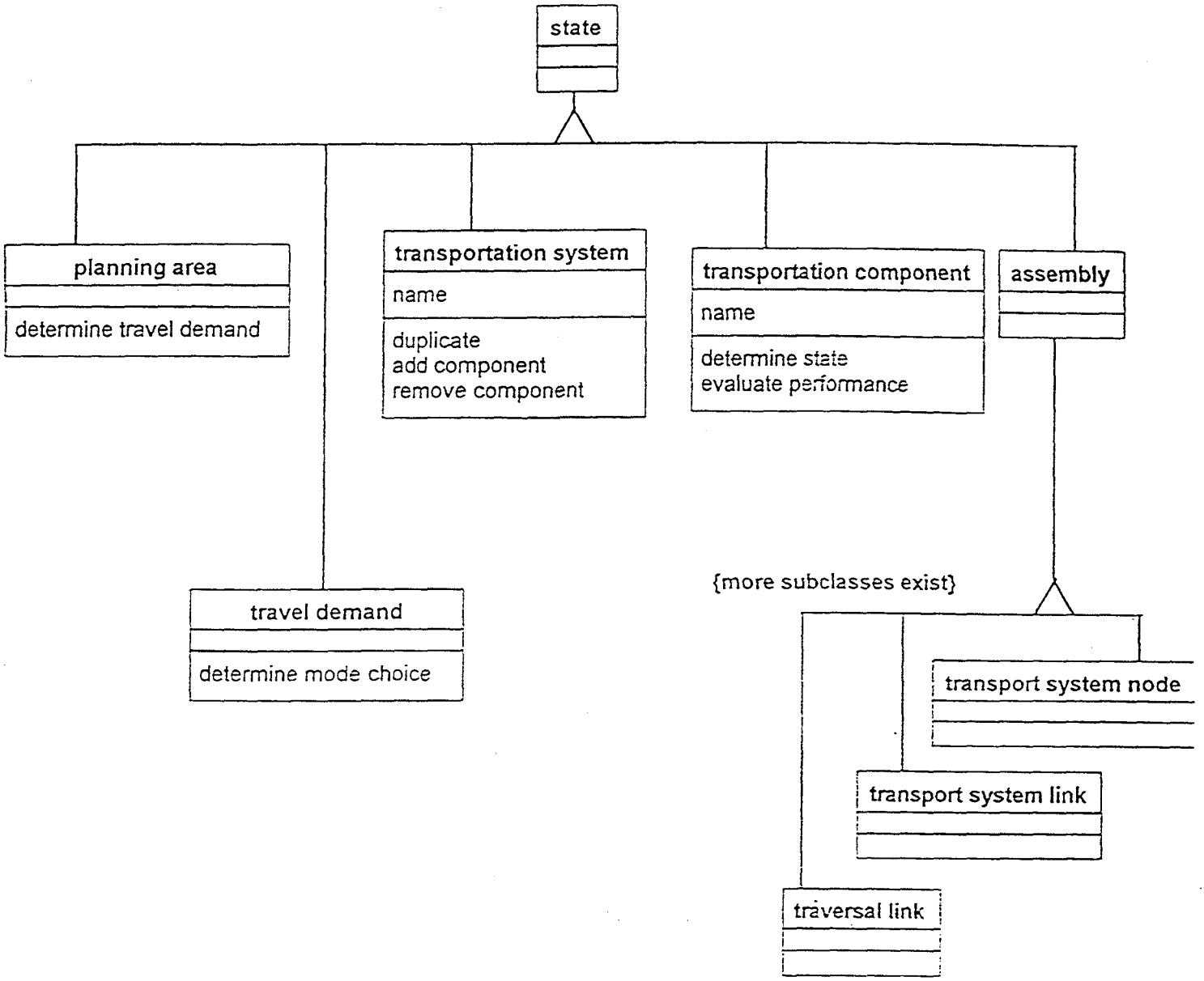

planning workbench
workbench clock
workbench extent
set workbench date
set workbench extent
perform planning process
manages
creates
phenomenon 1
temporal topology
temporal relationship
phenomenon
phenomenon 2
begins by
state
ends by
event
event timestamp
{ordered by time}
planning scenario
add experience
remove experience
planning event
perform
results in
experience
apply
1+


planning event
perform
FITS event
TRAMMS event
PASS event
TREADS event


FITS event
determine trn sys event
assemble trn sys event
allocate travel demand event
determine travel demand event
determine trn cmpnt function event


TRAMMS event
{more subclasses exist}
determine safety state event
determine pavement state event
determine traffic state event
determine roadway state event
determine bridge state event


experience
apply
{more subclasses may exist}
bridge experience
pavement experience
traffic experience
bridge treatment
bridge inspection
traffic record
pavement treatment
pavement inspection
bridge element experience
roadway experience
transportation system experience
roadway treatment
system demand
safety section experience
transport node experience
transport link experience
contains
crash
node demand
link demand


state
planning area
determine travel demand
transportation system
name
duplicate
add component
remove component
transportation component
name
determine state
evaluate performance
assembly
travel demand
determine mode choice
{more subclasses exist}
transport system node
transport system link
traversal link

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Module : fits6mod

Date : Wed Mar 29 09:28:28 1995

Language : NONE

OMT module : fits6mod Module modified : Wed Mar 29 09:28:22 1995

Description

The FITS module is the specification of the FITS Business system defined in Phase A. The primary responsibility of FITS is to manage an inventory of transportation components and to assemble them into specific systems in order to monitor and assess policy objectives.

Module parameter	Value	Inherit
Unique class	YES	system
Compound name punct.	#	system
Name length max.	24	system
Blank character	_	system
Default domain	string	system
ID domain	long_integer	system
Table name prefix		system
Table name suffix		system
Association impl.	buried_if_possible	system
Global column names		system
Association access	yes	system

Class parameter	Value	Inherit
Unique fields	YES	system
Unique operations	YES	system
Primary key impl.	system_generated	system

name	description
agency	class Any organization of legal standing with regulatory or fiscal interest in transportation, including federal agencies, states, local units of government, Metropolitan Planning Organizations, private transit operators, and Indian tribal governments. This class may be specialized, if necessary
air quality area	class A geographic area that does not (or previously did not) achieve one or more federal national ambient air quality standards.
air quality hotspot	subclass of transportation attachment A location with higher than ambiant levels of a pollutant. Hot spots may be attributed to such things as weather patterns, topography and traffic intensity.
airport	subclass of terminal A facility for transfering passengers or cargo onto and off of aircraft.
allocate travel demand event	subclass of FITS event An activity that allocates the total amount of person trips and commodity flows to each component of a transportation system.
anchor point	subclass of site A known point or location along a transportation corridor such as an intersection, bridge, monument, post, travelway terminus, etc.
anchor section	subclass of section The explicit domain of valid linear locations. The direction of the section establishes the positive direction.
assemble trn sys event	subclass of FITS event An activity that assembles functionally related transportation components into a transportation system.
assembly	subclass of state An assembly is a link class responsible for maintaining the assembly states of components and their respective containers.
bikeway	subclass of transport link Any road, street, path or way that is specifically designated in some manner as being open to bicycle travel.
bikeway system	subclass of transport system An ordered set of bikeways.
border crossing	subclass of customer site An international port of entry primarily between the U.S. and Canada or Mexico.
bridge	subclass of structure A structure, including supports, erected over a depression or an obstruction such as water, highway or railway, and having a track or passageway for carrying traffic or other moving loads and having an opening measured along the centerof the roadway of more than 20 feet between the undercopings of abutments or springlines or arches or extreme ends of openings of multiple boxes; may include multiple pipes where the clear distance between openings is less than half the

name	description
	smaller contiguous opening. AASHTO.
bridge element	class A component of a bridge. See PONTIS data dictionary for a list of bridge elements.
bridge element condition	class The condition and extent of the operational or physical characteristics of a bridge element. See PONTIS for an example of bridge element condition ratings.
bridge element experience	subclass of experience An experience that alters the state of a bridge element.
bridge experience	subclass of experience An experience that changes the state of a bridge.
bridge inspection	subclass of bridge experience A critical examination of a bridge conducted to improve knowledge about its state.
bridge system	subclass of component system An ordered set of bridges
bridge treatment	subclass of bridge experience Any action that alters the state of a bridge
busway	subclass of transport link An exclusive rights-of-way or fixed guideway reserved for buses.
component system	subclass of transportation system A transportation system composed of transportation elements.
continuous flow facility	subclass of transport link Any facility such as pipelines used for the transport of materials.
continuous flow system	subclass of transport system An ordered set of continuous flow components.
crash	class An incident involving at least one moter vehicle resulting in personal injury or property damage.
culvert	subclass of structure Any structure under a travelway having a clear opening of twenty feet or less as measured along the center of the travelway.
customer site	subclass of transport node A person trip or commodity flow generator; a trip origin or destination. Customer sites include specific trip generators such as major employers or aggregate sites such as Travel analysis zones.
depot	subclass of terminal A rail, bus, truck or marine terminal.
depot facility	subclass of public transportation asset The buildings, parking lots and other improvements associated with a depot.
determine bridge state event	subclass of TRAMMS event An activity that determines the state
determine pavement state event	subclass of TRAMMS event

name	description
	An activity that determine pavement states.
determine roadway state event	subclass of TRAMMS event An activity that determines the state of a roadway.
determine safety state event	subclass of TRAMMS event An activity that determines the state of a safety section or hazardous site.
determine traffic state event	subclass of TRAMMS event
determine travel demand event	subclass of FITS event An activity that determines the total anticipated person trips, commodity flows and characteristics for a transportation system.
determine trn cmpnt function event	subclass of FITS event An activity that determines which transportation components can be used to support a specific transportatiton system function.
determine trn sys event	subclass of FITS event An activity that determines the function (e.g., services) that characterizes the purpose of a transportation system.
event	subclass of phenomenon An isolated instant in time. An event is said to occur at time t if it occurs at any time during the chronon represented by t.
experience	subclass of event An event participated in. Significant experiences are those that change object states.
FITS event	subclass of planning event An activity that is part of the Functionally Integrated Transportation Business System.
fixture	subclass of transportation attachment Any equipment or hardware associated with a transportation system. Examples include RR crossing safety hardware, lighting fixtures, beam guard, signs, manholes, catch basins.
fleet	subclass of public transportation asset The vehicles used in a public transportaition system. "fleet" refers to highway vehicles; "rolling stock" refers to rail vehicles.
flexible pavement	subclass of pavement A pavement structure which maintains intimate contact with and distributes loads to the subgrade and depends upon aggregate interlock, particle friction and cohesion for stability.
freight distribution route	subclass of traversal A specified route identified as significant in the transport of freight, which must be considered in the transportaiton planning process.
geographic t	class A geographic object is an object representing a real or

name	description
	artificially defined phenomomen which has, or potentially has some kind of spatial or spatial temproal position. SAIF release 3.1, p. 49, April 1994.
geographic planning area	subclass of geographic object A set of spatial object that represent the location of a planning are at some cartographic scale and resolution.
geographic reference network	subclass of geographic object A set of spatial objects that represent the position of the reference network at some cartographic scale and resolution.
highway	subclass of transport link A public way dedicated to the purposes of vehicular travel, including the entire area within the right of way. This area may contain more than one roadway.
highway interchange	subclass of junction A system of interconnected ramps between two or more traveled ways that are grade separated
highway intersection	subclass of junction The general area where two or more highways join or cross. Highway intersections involving only two highway sections do not offer route choice and are used to represent significant change in highway section characteristics.
highway route	subclass of traversal The official designation of a highway, street or road
highway system	subclass of transport system Any designated collection of highways. Examples include National Highway system, Federal-aid System, Interstate Highway System, Strategic Highway Network.
highway traffic counter	subclass of transportation attachment A site where continuous traffic monitoring operations occur.
historic site	subclass of customer site A building, monument, park, cemetary or other site having public interest and national regional or local significance, which should be considered in the transportation planning process.
household	subclass of planning area A domestic establishment including the members of a family and others living in the same dwelling. Households are the basic unit of travel behavior and trip generation.
intermodal system	subclass of transport system An ordered set of transportation components from more than one mode or means of transportation.
junction	subclass of transport node A site that allows a change in travel route only (not transportation mode). Junctions connect two or more transportation links of the same type.
linear references	class The location of a site relative to a traversal in some system. A linear reference object is a container of linear locations represented by traversals and the reference point sites.

name	description
linear topology	class An enumerated spatial relationship between two components indicating intersection or connection. This relationship is used to support 'dynamic segmentation" analysis. See SAIF Release 3.1 discussion of SpatialTopology p. 108 ff. for analogous discussion.
link demand	subclass of transport link experience
maintenance facility	subclass of public transportation asset The buildings, parking lots and other improvements used for the upkeep [illegible] public [illegible]nsportation vehicles, machinery or equipment.
[illegible]tropolitan planning area	subclass of planning region The geographic area in which the metropolitan planning process must be carried out. See CFR 450.308
military installation	subclass of customer site A military base, fort, armory, field, etc.
national park	subclass of customer site A park operated by the U.S. Park Service
network topology	subclass of linear topology Each instance represents a connection between two components. This relationship is used to define network structures. See SAIF release 3.1 p 124 connected_ to class for discussion
node demand	subclass of transport node experience
noise barrier	subclass of structure A structure designed to mitigate the impact of transportation realted noise on surrounding areas.
objective	class A statement of direction and extent for the availability, quality or performance of transportation. Source: PFS Phase A Data Dictionary.
PASS event	subclass of planning event An activity that is part of the Performance Assessment [illegible]ness System.
pavement	[illegible]lass of transportation element A pavement course or layer, including base course and overlays.
pavement experience	subclass of experience An event that alters a flexible pavement state.
[illegible]vement inspection	subclass of pavement experience A critical examination of a pavement conducted to improve knowledge about its state.
pavement structure	subclass of pavement The combination of all pavement courses placed on a subgrade to support traffic load and distribute it to the roadbed.. Used to monitor composite strength and deflection indicators.
pavem[illegible]stem	subclass of component system An ordered set of pavement structures.
pavement treatment	subclass of pavement experience Any action that alters the state of a pavement.
pedestria[illegible]m	subclass of transport system

name	description
	An ordered set of pedestrianways.
pedestrianway	subclass of transport link A rights-of-way dedicated [illegible] the exclusive use of pedestrians. Includes people movers, skyways, sidewalks.
phenomenon	class A significant o[illegible]ce or event. Used as the most general abstract superclass in the model. Every object is or represents, by definition, a phenomenon.
pipeline farm	subclass of terminal A facility for transfering materials from pipelines onto trucks or rail cars.
planning area	subclass of state A territorial unit used in land use and transportation planning analysis.
planning corridor	subclass of plannin[illegible]ion an existing or proposed transportation corridor.
planning event	subclass of event A unit of planning activity that, when complete, leaves the enterprise in a consistent state.
planning region	subclass of planning area The entire planning area.
planning scenario	subclass of event A hypothesized chain of experiences.
planning workbench	class The planning workbench is the mechanism for accessing, through a single, consistent interface all of the operationas and objects defined by the transportation planning business systems architecture. see white paper dated 10/17/94.
port	subclass of terminal A facility for loading and offloading passengers and cargo from ships
public transportation asset	class Any p[illegible]ic transportation facility or equipment.
public transportation equipment	subclass of public transportation asset Unstationary public transportation assets.
public transportation system	subclass of transport system A set of components that p[illegible]ides transportatio[illegible]rvice to the public using vehicles that transport more [illegible]one person for compensation. Subclasses may include public transit and paratransit systems.
rail system	subclass of tr[illegible]port system An ordered set [illegible]ll components. E.g., a rail[illegible]d.
railroad crossing	subclass of transportation attachme[illegible] [illegible]rade intersection of a railway and a highway.
railway	subclass of transport link A dedicated rights-of-way reserved for train travel. includes light rail, heavy rail, rapid rail, commuter rail.
recreation area	subclass of customer site A significant scenic or recreational trav[illegible]tination.
reference network	class

name	description
	A frame of reference, or datum, used to control linear locations. The reference network is used for both field locations and data base representations of those locations.
reference post	subclass of traversal reference point A numbered post placed along a travelway. The number may represent a milepoint or may be arbitrary.
retaining wall	subclass of structure A structure used to retain soil.
rigid pavement	subclass of pavement A pavement structure which distributes loads to the subgrade having as one course a portland cement concrete slab of relatively high bending resistance.
roadway	subclass of transportation element The portion of a highway designed or built for vehicular use. includes the traveled way, shoulders, gutters and auxiliary lanes.
roadway experience	subclass of experience An event that affects the state of a roadway.
roadway system	subclass of component system An ordered set of roadway sections.
roadway treatment	subclass of roadway experience An action that alters the state of a roadway. Actions include construction, maintenance and rehabilitation.
safety hotspot	subclass of transportation attachment A location with greater than expected numbers of crashes. A hazardous location.
safety section	subclass of transportation element A location established to monitor crash incidents and establish crash rates.
safety section experience	subclass of experience
safety system	subclass of component system An ordered set of safety sections
section	subclass of transportation component A linear portion of a transportation system or its components defined as the portion of the component located between two sites.
site	subclass of transportation component A transportation component that exists or occurs at a specific place.
state	subclass of phenomenon A condition of being defined by constant attributes and link relationships. A state can be thought of as a portion of time between events. A State with no end state is current in when valid time equals system time.
statewide planning area	subclass of planning region A territorial unit comprising one of the 50 United States, Puerto Rico, or the District of Columbia..
street address	subclass of traversal reference point A geographic location of a building.
structure	subclass of transportation element An engineered works such as bridge, noise barrier, box culvert.
system dem	subclass of transportation system experience The actual or latent demand for persons of commodity movement

name	description
	on a transportation system.
temporal topology	class See discussion in SAIF release3.1 p. 118 ff.
terminal	subclass of transport node A facility allowing intermodal transfer of passengers or goods.
traffic experience	subclass of experience An event that alters the state of a traffic section.
traffic record	subclass of traffic experience The results of a traffic census.
traffic section	subclass of transportation element A statistical section used to monitor traffic statistics.
traffic system	subclass of component system An ordered set of traffic sections
trail	subclass of transport link A marked or established path used by pedestrians, bicycles or horses, especially through forests or other recreational areas.
trail system	subclass of transport system An ordered set of trails.
TRAMMS event	subclass of planning event An activity that is part of the Transportation Modelling and Monitoring Business System.
transit route	subclass of traversal A designated, specified path to which a transit vehicle is assigned.
transit stop	subclass of traversal reference point An area where passengers wait for, board, alight and transfer between transit units. It is indicated by distinctive signs or pavement and curb markings.
transport link	subclass of section A transport link is and historical, exisitng or anticipated travelway used to transport passengers or goods. The direction of the links establishes the primary direction in which the traversal is said to "run."
transport link experience	subclass of experience
transport node	subclass of site A transport node is a place where travel originates (or ends) or a facility allowing for a change in transportation mode or travel route.
transport node experience	subclass of experience
transport system	subclass of transportation system A transport system is an ordered collection of transportation components serving a transportation function in support of transportation objectives (i.e., a FITS). These systems can be single mode (eg., highway systems), multi modal (eg., public transportation buses + light rail) or intermodal (eg., freight or passenger based). The default transport system consists of all transportation choices within a predetermined region.
transport system link	subclass of assembly An object responsible for maintaing the as ies of transport systems and their links.

name	description
transport system node	subclass of assembly
transportation attachment	subclass of site A site of interest or facility associated with a transportation system that is not an element of a system.
transportation complex	class A collection of interconnected transportation components. Complexes are used to manage groups of components i.e. act as "containers." They are the primary mechanism for determining multi-component performance. e.g., pavement sections may collaborate with the traffic section complex
transportation component	subclass of state An object regarded as part of a transportation system.
transportation element	subclass of section Any transportation related object that affects or monitors the availability, quality or performance of transportation functions or services.
transportation system	subclass of state An ordered set of transportation components.
transportation system experience	subclass of experience A experience that alters the state of a transportation system.
travel analysis zone	subclass of planning area A division of a study area used for travel demand analysis purposes. A planning region is divided into zones, the number and size of which depend on land uses in the area, transportation access, census boundaries and political boundaries. Zone boundaries are defined so that land uses and activities are homogeneous, to the extent practicable. Travel analysis zones may be coincident with census blocks.
travel demand	subclass of state The actual or latent movement of people or freight between two points for a specific purpose. Each trip (or aggregation of trips is characterized by mode choice.
traversal	class The geographical route, path or course designated for travel or followed by a vehicle or traveler. Traversals also may be names of designated paths through a transportation system. Examples include mainline routes, business routes, spurs, county routes, scenic, hazmat.
traversal link	subclass of assembly An object responsible for maintaining the history of traversal and link assemblies.
traversal reference at	subclass of transportation attachment

name	description
	A point on a traversal that can be easily identified and whose identity and location are known.
TREADS event	subclass of planning event An activity that is part of the Treatment Development Business System.
trn service center	subclass of transportation attachment The area and service used to enhance, regulate or respond to transportation. Examples include traffic control centers, police and other dispatch centers, weigh-in-motion sites, toll plazas, tourist rest areas.
tunnel	subclass of structure An enclosed passageway through or under an obstruction such as a city, river, mountain, or harbor.
water transport system	subclass of transport system An ordered set of marine transport components.
waterway	subclass of transport link A navigable water course, including canals, used for the transport of people or goods.

Name	Subclass of	Superclass of
agency		

Description

Any organization of legal standing with regulatory or fiscal interest in transportation, including federal agencies, states, local units of government, Metropolitan Planning Organizations, private transit operators, and Indian tribal governments.
This class may be specialized, if necessary

Class parameter	Value	Inherit
Abstract	YES	
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

Relation	Multiplicity	Related to	Comments
cooperates with	1 - *	agency	A lead agency has the principal responsibility for preparing transportation plans, for preparing environmental documents and for carrying out or approving projects that may have *significant* impacts on the environment.
cooperates with	1 - *	agency	A lead agency has the principal responsibility for preparing transportation plans, for preparing environmental documents and for carrying out or approving projects that may have significant impacts on the environment.
establishes	1 - *	objective	
has inter	* - *	planning area	

Name	Subclass of	Superclass of
air quality area		

Description

A geographic area that does not (or previously did not) achieve one or more federal national ambient air quality standards.

Class parameter	Value	Inherit
Abstract	NO	system
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

Relation	Multiplicity	Related to	Comments
has been designated	* - 1	*planning region*	

Name	Subclass of	Superclass of
air quality hotspot	transportation attachment	

Description

A location with higher than ambient levels of a pollutant. Hot spots may be attributed to such things as weather patterns, topography and traffic intensity.

Class parameter	Value	Inherit
Abstract	NO	system
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

Name	Subclass of	Superclass of
airport	terminal	

Description

A facility for transfering passengers or cargo onto and off of aircraft.

Class parameter	Value	Inherit
Abstract	NO	system
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

Name	Subclass of	Superclass of
allocate travel demand event	FITS event	

Description

An activity that allocates the total amount of person trips and commodity flows to each component of a transportation system.

Class parameter	Value	Inherit
Abstract	NO	system
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

Name	Subclass of	Superclass of
anchor point	site	

Description

A known point or location along a transportation corridor such as an intersection, bridge, monument, post, travelway terminus, etc.

Class parameter	Value	Inherit
Abstract	NO	system
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

Attribute	Domain	Default value	ClassReq.	
description			NO	NO
location			NO	NO

Relation	Multiplicity	Related to	Comments
from	1 - *	anchor section	
reference network# anchor point	1 - *	reference network	
to	1 - *	anchor section	

OMT module : fits6mod Module modified : Wed Mar 29 09:28:22 1995
Class name : anchor section Report page : 1 Overall page : 18

Name	Subclass of	Superclass of
anchor section	section	

Description

The explicit domain of valid linear locations. The direction of the section establishes the positive direction.

Class parameter	Value	Inherit
Abstract	NO	system
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

Attribute	Domain	Default value	ClassReq.	
distance			NO	NO

Relation	Multiplicity	Related to	Comments
from	1 - *	anchor point	
is located on	1 - *	transport node	
reference network# anchor section	1 - *	reference network	
to	1 - *	anchor point	

OMT module : fits6mod Module modified : Wed Mar 29 09:28:22 1995
Class name : assemble trn sys event Report page : 1 Overall page : 19

Name	Subclass of	Superclass of
assemble trn sys event	FITS event	

Description

An activity that assembles functionally related transportation components into a transportation system.

Class parameter	Value	Inherit
Abstract	NO	system
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

Name	Subclass of	Superclass of
assembly	state	traversal link transport system link transport system node

Description

An assembly is a link class responsible for maintaining the assembly states of components and their respective containers.

Class parameter	Value	Inherit
Abstract	YES	
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

Name	Subclass of	Superclass of
bikeway	transport link	

Description

Any road, street, path or way that is specifically designated in some manner as being open to bicycle travel.

Class parameter	Value	Inherit
Abstract	NO	system
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

OMT module : fits6mod Module modified : Wed Mar 29 09:28:22 1995
Class name : bikeway system Report page : 1 Overall page : 22

Name	Subclass of	Superclass of
bikeway system	transport system	

Description

An ordered set of bikeways.

Class parameter	Value	Inherit
Abstract	NO	system
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

OMT module : fits6mod Module modified : Wed Mar 29 09:28:22 1995
Class name : border crossing Report page : 1 Overall page : 23

Name	Subclass of	Superclass of
border crossing	customer site	

Description

An international port of entry primarily between the U.S. and Canada or Mexico.

Class parameter	Value	Inherit
Abstract	NO	system
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

Name	Subclass of	Superclass of
bridge	structure	

Description

A structure, including supports, erected over a depression or an obstruction such as water, highway or railway, and having a track or passageway for carrying traffic or other moving loads and having an opening measured along the centerof the roadway of more than 20 feet between the undercopings of abutments or springlines or arches or extreme ends of openings of multiple boxes; may include multiple pipes where the clear distance between openings is less than half the smaller contiguous opening. AASHTO.

Class parameter	Value	Inherit
Abstract	YES	
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

Attribute	Domain	Default value	ClassReq.	
bridge identification			NO	NO
geometrics			NO	NO
load rating			NO	NO
serviceability			NO	NO
structure components			NO	NO
user costs			NO	NO

Relation	Multiplicity	Related to	Comments
contains	1 - *	bridge element	

Name	Subclass of	Superclass of
bridge element		

Description

A component of a bridge. See PONTIS data dictionary for a list of bridge elements.

Class parameter	Value	Inherit
Abstract	NO	system
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

Attribute	Domain	Default value	ClassReq.	
bridge element condition units environment			NO	NO

Relation	Multiplicity	Related to	Comments
contains	1 - *	bridge	
is in	* - 1	bridge element condition	

Name	Subclass of	Superclass of
bridge element condition		

Description

The condition and extent of the operational or physical characteristics of a bridge element. See PONTIS for an example of bridge element condition ratings.

Class parameter	Value	Inherit
Abstract	NO	system
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

Attribute	Domain	Default value	ClassReq.	
condition			NO	NO
condition state description			NO	NO
recommended actions			NO	NO

Relation	Multiplicity	Related to	Comments
is in	* - 1	bridge element	

Name	Subclass of	Superclass of
bridge element experience	experience	

Description

An experience that alters the state of a bridge element.

Class parameter	Value	Inherit
Abstract	NO	system
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

OMT module : fits6mod Module modified : Wed Mar 29 09:28:22 1995
Class name : bridge experience Report page : 1 Overall page : 28

Name	Subclass of	Superclass of
bridge experience	experience	bridge inspection bridge treatment

Description

An experience that changes the state of a bridge.

Class parameter	Value	Inherit
Abstract	YES	
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

OMT module : fits6mod Module modified : Wed Mar 29 09:28:22 1995
Class name : bridge inspection Report page : 1 Overall page : 29

Name	Subclass of	Superclass of
bridge inspection	bridge experience	

Description

A critical examination of a bridge conducted
to improve knowledge about its state.

Class parameter	Value	Inherit
Abstract	NO	system
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

Name	Subclass of	Superclass of
bridge system	component system	

Description

An ordered set of bridges

Class parameter	Value	Inherit
Abstract	NO	system
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

Name	Subclass of	Superclass of
bridge treatment	bridge experience	

Description

Any action that alters the state of a bridge

Class parameter	Value	Inherit
Abstract	NO	system
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

Name	Subclass of	Superclass of
busway	transport link	

Description

An exclusive rights-of-way or fixed guideway reserved for buses.

Class parameter	Value	Inherit
Abstract	NO	system
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

Name	Subclass of	Superclass of
component system	transportation system	safety system traffic system bridge system pavement system roadway system

Description

A transportation system composed of transportation elements.

Class parameter	Value	Inherit
Abstract	YES	
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

Name	Subclass of	Superclass of
continuous flow facility	transport link	

Description

Any facility such as pipelines used for the transport of materials.

Class parameter	Value	Inherit
Abstract	NO	system
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

Name	Subclass of	Superclass of
continuous flow system	transport system	

Description

An ordered set of continuous flow components.

Class parameter	Value	Inherit
Abstract	NO	system
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

Name	Subclass of	Superclass of
crash		

Description

An incident involving at least one moter vehicle resulting in personal injury or property damage.

Class parameter	Value	Inherit
Abstract	NO	system
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

Relation	Multiplicity	Related to	Comments
contains	* - 1	safety section experience	
is a collection of	* - 0-1	safety hotspot	

Name	Subclass of	Superclass of
culvert	structure	

Description

Any structure under a travelway having a clear opening of twenty feet or less as measured along the center of the travelway.

Class parameter	Value	Inherit
Abstract	YES	
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

Name	Subclass of	Superclass of
customer site	transport node	military installation historic site national park recreation area border crossing

Description

A person trip or commodity flow generator; a trip origin or destination.

Customer sites include specific trip generators such as major employers or aggregate sites such as Travel analysis zones.

Class parameter	Value	Inherit
Abstract	YES	
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

Name	Subclass of	Superclass of
depot	terminal	

Description

A rail, bus, truck or marine terminal.

Class parameter	Value	Inherit
Abstract	NO	system
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

OMT module : fits6mod Module modified : Wed Mar 29 09:28:22 1995
Class name : depot facility Report page : 1 Overall page : 40

Name	Subclass of	Superclass of
depot facility	public transportation asset	

Description

The buildings, parking lots and other improvements associated with a depot.

Class parameter	Value	Inherit
Abstract	NO	system
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

OMT module : fits6mod Module modified : Wed Mar 29 09:28:22 1995
Class name : determine bridge state event Report page : 1 Overall page : 41

Name	Subclass of	Superclass of
determine bridge state event	TRAMMS event	

Description

An activity that determines the state

Class parameter	Value	Inherit
Abstract	NO	system
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

OMT module : fits6mod Module modified : Wed Mar 29 09:28:22 1995
Class name : determine pavement state event Report page : 1 Overall page : 42

Name	Subclass of	Superclass of
determine pavement state event	TRAMMS event	

Description

An activity that determine pavement states.

Class parameter	Value	Inherit
Abstract	NO	system
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

OMT module : fits6mod Module modified : Wed Mar 29 09:28:22 1995
Class name : determine roadway state event Report page : 1 Overall page : 43

Name	Subclass of	Superclass of
determine roadway state event	TRAMMS event	

Description

An activity that determines the state of a roadway.

Class parameter	Value	Inherit
Abstract	NO	system
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

OMT module : fits6mod Module modified : Wed Mar 29 09:28:22 1995
Class name : determine safety state event Report page : 1 Overall page : 44

Name	Subclass of	Superclass of
determine safety state event	TRAMMS event	

Description

An activity that determines the state of a safety section or hazardous site.

Class parameter	Value	Inherit
Abstract	NO	system
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

OMT module : fits6mod Module modified : Wed Mar 29 09:28:22 1995
Class name : determine traffic state event Report page : 1 Overall page : 45

Name	Subclass of	Superclass of
determine traffic state event	TRAMMS event	

Description

Class parameter	Value	Inherit
Abstract	NO	system
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

Name	Subclass of	Superclass of
determine travel demand event	FITS event	

Description

An activity that determines the total anticipated person trips, commodity flows and characteristics for a transportation system.

Class parameter	Value	Inherit
Abstract	NO	system
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

Name	Subclass of	Superclass of
determine trn cmpnt function event	FITS event	

Description

An activity that determines which transp... ion components can be used to support a specific transportatiton system function.

Class parameter	Value	Inherit
Abstract	NO	system
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

Name	Subclass of	Superclass of
determine trn sys FITS event		

Description

An activity that determines the function (e.g., services) that characterizes the purpose of a transportation system.

Class parameter	Value	Inherit
Abstract	NO	system
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

Name	Subclass of	Superclass of
event	phenomenon	experience planning event planning scenario

Description

An isolated instant in time. An event is said to occur at time t if it occurs at any time during the chronon represented by t.

Class parameter	Value	Inherit
Abstract	YES	
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

Attribute	Domain	Default value	ClassReq.	
event timestamp			NO	NO

Relation	Multiplicity	Related to	Comments
begins by	1 - *	state	
creates	1 - *	planning workbench	
ends by	0-1 - *	state	
planning scenario# event	1 - *	planning scenario	

Name	Subclass of	Superclass of
experience	event	transportation system experience transport node experience transport link experience bridge experience traffic experience roadway experience pavement experience safety section experience bridge element experience

Description

An event participated in. Significant experiences are those that change object states.

Class parameter	Value	Inherit
Abstract	YES	
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

Relation	Multiplicity	Related to	Comments
alters	1 - *	transportation component	
contains	* - 1	transportation system	
lifespan	0-1 - *	experience	The lifespan of an object is the set of all state altering experiences associated with that object.
lifespan	0-1 - *	experience	The lifespan of an object is the set of all state altering experiences associated with that object.
results in	1-2147483646 - 1	planning event	

Name	Subclass of	Superclass of
FITS event	planning event	determine trn sys event allocate travel demand event assemble trn sys event determine travel demand event determine trn cmpnt function event

Description

An activity that is part of the Functionally Integrated Transportation Business System.

Class parameter	Value	Inherit
Abstract	YES	
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

Name	Subclass of	Superclass of
fixture	transportation attachment	

Description

Any equipment or hardware associated with a transportation system. Examples include RR crossing safety hardware, lighting fixtures, beam guard, signs, manholes, catch basins.

Class parameter	Value	Inherit
Abstract	NO	system
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

Name	Subclass of	Superclass of
fleet	public transportation asset	

Description

The vehicles used in a public transportaition system. "fleet" refers to highway vehicles; "rolling stock" refers to rail vehicles.

Class parameter	Value	Inherit
Abstract	NO	system
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

OMT module : fits6mod Module modified : Wed Mar 29 09:28:22 1995
Class name : flexible pavement Report page : 1 Overall page : 54

Name	Subclass of	Superclass of
flexible pavement	pavement	

Description

A pavement structure which maintains intimate contact with and distributes loads to the subgrade and depends upon aggregate interlock, particle friction and cohesion for stability.

Class parameter	Value	Inherit
Abstract	NO	system
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

Attribute	Domain	Default value	ClassReq.	
rutting			NO	NO

OMT module : fits6mod Module modified : Wed Mar 29 09:28:22 1995
Class name : freight distribution route Report page : 1 Overall page : 55

Name	Subclass of	Superclass of
freight distribution route	traversal	

Description

A specified route identified as significant in the transport of freight, which must be considered in the transportaiton planning process.

Class parameter	Value	Inherit
Abstract	NO	system
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

OMT module : fits6mod Module modified : Wed Mar 29 09:28:22 1995
Class name : geographic object Report page : 1 Overall page : 56

Name	Subclass of	Superclass of
		geographic planning area
		geographic reference network
geographic object		

Description

A geographic object is an object representing a real or artificially defined phenomonen which has, or potentially has some kind of spatial or spatial temproal position. SAIF release 3.1, p. 49, April 1994.

Class parameter	Value	Inherit
Abstract	YES	
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

Attribute	Domain	Default value	ClassReq.	
position			NO	NO

OMT module : fits6mod Module modified : Wed Mar 29 09:28:22 1995
Class name : geographic planning area Report page : 1 Overall page : 57

Name	Subclass of	Superclass of
geographic planning area	geographic object	

Description

A set of spatial object that represent the location of a planning are at some cartographic scale and resolution.

Class parameter	Value	Inherit
Abstract	NO	system
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

Relation	Multiplicity	Related to	Comments
represents	* - 1	planning area	

Name	Subclass of	Superclass of
geographic reference network	geographic object	

Description

A set of spatial objects that represent the position of the reference network at some cartographic scale and resolution.

Class parameter	Value	Inherit
Abstract	NO	system
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

Relation	Multiplicity	Related to	Comments
represents	* - 1	reference network	

Name	Subclass of	Superclass of
highway	transport link	

Description

A public way dedicated to the purposes of vehicular travel, including the entire area within the right of way. This area may contain more than one roadway.

Class parameter	Value	Inherit
Abstract	NO	system
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

Attribute	Domain	Default value	ClassReq.	
functional classification			NO	NO

OMT module : fits6mod Module modified : Wed Mar 29 09:28:22 1995
Class name : highway interchange Report page : 1 Overall page : 60

Name	Subclass of	Superclass of
highway interchange	junction	

Description

A system of interconnected ramps between two or more traveled ways that are grade separated

Class parameter	Value	Inherit
Abstract	NO	system
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

OMT module : fits6mod Module modified : Wed Mar 29 09:28:22 1995
Class name : highway intersection Report page : 1 Overall page : 61

Name	Subclass of	Superclass of
highway intersection	junction	

Description

The general area where two or more highways join or cross.
Highway intersections involving only two highway sections do not offer route choice and are used to represent
significant change in highway section characteristics.

Class parameter	Value	Inherit
Abstract	NO	system
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

Name	Subclass of	Superclass of
highway route	traversal	

Description

The official designation of a highway, street or road

Class parameter	Value	Inherit
Abstract	NO	system
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

Attribute	Domain	Default value	Class	Req.
direction			NO	NO
name			NO	NO
number			NO	NO
system			NO	NO

Name	Subclass of	Superclass of
highway system	transport system	

Description

Any designated collection of highways. Examples include National Highway system, Federal-aid System, Interstate Highway System, Strategic Highway Network.

Class parameter	Value	Inherit
Abstract	NO	system
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

Name	Subclass of	Superclass of
highway traffic counter	transportation attachment	

Description

A site where continuous traffic monitoring operations occur.

Class parameter	Value	Inherit
Abstract	NO	system
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

Attribute	Domain	Default value	Class	Req.
speed			NO	NO
traffic volume			NO	NO
turning movement			NO	NO
vehicle classification			NO	NO
vehicle weight			NO	NO

Name	Subclass of	Superclass of
historic site	customer site	

Description

A building, monument, park, cemetary or other site having public interest and national regional or local significance, which should be considered in the transportation planning process.

Class parameter	Value	Inherit
Abstract	NO	system
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

Name	Subclass of	Superclass of
household	planning area	

Description

A domestic establishment including the members of a family and others living in the same dwelling. Households are the basic unit of travel behavior and trip generation.

Class parameter	Value	Inherit
Abstract	NO	system
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

Attribute	Domain	Default value	Class	Req.
economic status			NO	NO
vehicle availability			NO	NO
ethnicity				

Name	Subclass of	Superclass of
intermodal system	transport system	

Description

An ordered set of transportation components from more than one mode or means of transportation.

Class parameter	Value	Inherit
Abstract	NO	system
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

Name	Subclass of	Superclass of
junction	transport node	highway intersection highway interchange

Description

A site that allows a change in travel route only (not transportation mode). Junctions connect two or more transportation links of the same type.

Class parameter	Value	Inherit
Abstract	YES	
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

Name	Subclass of	Superclass of
linear references		

Description

The location of a site relative to a traversal in some system. A linear reference object is a container of linear locations represented by traversals and their reference point sites.

Class parameter	Value	Inherit
Abstract	NO	system
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

Relation	Multiplicity	Related to	Comments
is addressed by	* - 1	site	
is referenced by	1 - *	traversal reference point	
linear references# traversal	1 - *	traversal	

Name	Subclass of	Superclass of
linear topology		network topology

Description

An enumerated spatial relationship between two components indicating intersection or connection. This relationship is used to support "dynamic segmentation" analysis.
See AIF Release 3.1 discussion of SpatialTopology p. 108 ff. for analogous discussion.

Class parameter	Value	Inherit
Abstract	NO	system
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

Attribute	Domain	Default value	ClassReq.	
linear relationship			NO	NO

Relation	Multiplicity	Related to	Comments
component 1	1 - 1	transportation component	
component 2	1 - 1	transportation component	

Name	Subclass of	Superclass of
link demand	transportation experience	

Description

Class parameter	Value	Inherit
Abstract	NO	system
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

Name	Subclass of	Superclass of
maintenance facility	public transportation asset	

Description

The buildings, parking lots and other improvements used for the upkeep of public transportation vehicles, machinery or equipment.

Class parameter	Value	Inherit
Abstract	NO	system
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

Name	Subclass of	Superclass of
metropolitan planning area	planning region	

Description

The geographic area in which the metropolitan planning process must be carried out. See CFR 450.308

Class parameter	Value	Inherit
Abstract	NO	system
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

Name	Subclass of	Superclass of
military installation	customer site	

Description

A military base, fort, armory, field, etc.

Class parameter	Value	Inherit
Abstract	NO	system
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

Name	Subclass of	Superclass of
national park	customer site	

Description

A park operated by the U.S. Park Service

Class parameter	Value	Inherit
Abstract	NO	system
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

Name	Subclass of	Superclass of
network topology	linear topology	

Description

Each instance represents a connection between two components. This relationship is used to define network structures.
See SAIF release 3.1 p 124 connected_ to class for discussion

Class parameter	Value	Inherit
Abstract	NO	system
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

Attribute	Domain	Default value	Class	Req.
connection direction			NO	NO

Relation	Multiplicity	Related to	Comments
defines a transportation system network	1 - *	transportation system	

Name	Subclass of	Superclass of
node demand	transport node experience	

Description

Class parameter	Value	Inherit
Abstract	NO	system
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

Name	Subclass of	Superclass of
noise barrier	structure	

Description

A structure designed to mitigate the impact of transportation realted noise on surrounding areas.

Class parameter	Value	Inherit
Abstract	YES	
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

Name	Subclass of	Superclass of
objective		

Description

A statement of direction and extent for availability, quality or performance of transportation. Source: PFS Phase A Data Dictionary.

Class parameter	Value	Inherit
Abstract	NO	system
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

Attribute	Domain	Default value	ClassReq.	
functional objective			NO	NO
geographic objective				
temporal objective				

Relation	Multiplicity	Related to	Comments
establishes	1 - *	agency	
is set for	* - 1	transport system	

OMT module : fits6mod Module modified : Wed Mar 29 09:28:22 1995
Class name : PASS event Report page : 1 Overall page : 80

Name	Subclass of	Superclass of
PASS event	planning event	

Description

An activity that is part of the Performance Assessment Business System.

Class parameter	Value	Inherit
Abstract	YES	
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

OMT module : fits6mod Module modified : Wed Mar 29 09:28:22 1995
Class name : pavement Report page : 1 Overall page : 81

Name	Subclass of	Superclass of
pavement	transportation element	flexible pavement rigid pavement pavement structure

Description

A pavement course or layer, including base course and overlays.

Class parameter	Value	Inherit
Abstract	YES	
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

Attribute	Domain	Default value	ClassReq.	
distress			NO	NO
remaining service life			NO	NO
ride			NO	NO
roughness			NO	NO
surface friction			NO	NO

Relation	Multiplicity	Related to	Comments
provides	* - 1	pavement structure	

Name	Subclass of	Superclass of
pavement experience	experience	pavement treatment
		pavement inspection

Description

An event that alters a flexible pavement state.

Class parameter	Value	Inherit
Abstract	YES	
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

Name	Subclass of	Superclass of
pavement inspection	pavement experience	

Description

A critical examination of a pavement conducted to improve knowledge about its state.

Class parameter	Value	Inherit
Abstract	NO	system
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

Name	Subclass of	Superclass of
pavement structure	pavement	

Description

The combination of all pavement courses placed on a subgrade to support traffic load and distribute it to the roadbed.. Used to monitor composite strength and deflection indicators.

Class parameter	Value	Inherit
Abstract	NO	system
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

Relation	Multiplicity	Related to	Comments
provides	* - 1	pavement	

Name	Subclass of	Superclass of
pavement system	component system	

Description

An ordered set of pavement structures.

Class parameter	Value	Inherit
Abstract	NO	system
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

Name	Subclass of	Superclass of
pedestrianway	transport link	

Description

A rights-of-way dedicated for the exclusive use of pedestrians. Includes people movers, skyways, sidewalks.

Class parameter	Value	Inherit
Abstract	NO	system
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

Name	Subclass of	Superclass of
		state
		event
phenomenon		

Description

A significant occurance or event. Used as the most general abstract superclass in the model. Every object is or represents, by definition, a phenomenon.

Class parameter	Value	Inherit
Abstract	YES	
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

Relation	Multiplicity	Related to	Comments
manages	* - 1	planning workbench	
phenomenon 1	1 - 1	temporal topology	
phenomenon 2	1 - 1	temporal topology	

Name	Subclass of	Superclass of
pavement treatment	pavement experience	

Description

Any action that alters the state of a pavement.

Class parameter	Value	Inherit
Abstract	NO	system
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

Name	Subclass of	Superclass of
pedestrian system	transport system	

Description

An ordered set of pedestrianways.

Class parameter	Value	Inherit
Abstract	NO	system
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

OMT module : fits6mod Module modified : Wed Mar 29 09:28:22 1995
Class name : pipeline farm Report page : 1 Overall page : 90

Name	Subclass of	Superclass of
pipeline farm	terminal	

Description

A facility for transfering materials from pipelines onto trucks or rail cars.

Class parameter	Value	Inherit
Abstract	NO	system
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

OMT module : fits6mod Module modified : Wed Mar 29 09:28:22 1995
Class name : planning area Report page : 1 Overall page : 91

Name	Subclass of	Superclass of
planning area	state	travel analysis zone household planning region

Description

A territorial unit used in land use and transportation planning analysis.

Class parameter	Value	Inherit
Abstract	YES	
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

Relation	Multiplicity	Related to	Comments
has interest in	* - *	agency	
is component of	1 - *	planning region	
is served by	* - 1	transport system	
planning area# planning area	1 - *	planning area	
planning area# planning area	1 - *	planning area	
represents	* - 1	geographic planning area	
travel analysis zone#planning area	1 - *	travel analysis zone	

Name	Subclass of	Superclass of
planning corridor	planning region	

Description

an existing or proposed transportation corridor.

Class parameter	Value	Inherit
Abstract	NO	system
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

Name	Subclass of	Superclass of
planning event	event	FITS event TRAMMS event PASS event TREADS event

Description

A unit of planning activity that, when complete, leaves the enterprise in a consistent state.

Class parameter	Value	Inherit
Abstract	YES	
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

Relation	Multiplicity	Related to	Comments
results in	1-2147483646 - 1	experience	

Name	Subclass of	Superclass of
planning region	planning area	statewide planning area metropolitan planning area planning corridor

Description

The entire planning area.

Class parameter	Value	Inherit
Abstract	NO	system
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

Attribute	Domain	Default value	ClassReq.	
economic growth demographics			NO	NO

Relation	Multiplicity	Related to	Comments
has been designated	* - 1	air quality area	
is component of	1 - *	planning area	

Name	Subclass of	Superclass of
planning scenario event		

Description

A hypothesized chain of experiences.

Class parameter	Value	Inherit
Abstract	NO	system
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

Relation	Multiplicity	Related to	Comments
planning scenario# event	1 - *	event	

Name	Subclass of	Superclass of
planning workbench		

Description

The planning workbench is the mechanism for accessing, through a single, consistent interface all of the operationas and objects defined by the transportation planning business systems architecture. see white paper dated 10/17/94.

Class parameter	Value	Inherit
Abstract	NO	system
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

Attribute	Domain	Default value	Class	Req.
workbench clock			NO	NO
workbench extent			NO	NO

Relation	Multiplicity	Related to	Comments
creates	1 - *	event	
manages	* - 1	phenomenon	

Name	Subclass of	Superclass of
port	terminal	

Description

A facility for loading and offloading passengers and cargo from ships

Class parameter	Value	Inherit
Abstract	NO	system
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

Name	Subclass of	Superclass of
		fleet
		public transportation equipment
		maintenance facility
		depot facility
public transportation asset		

Description

Any public transportation facility or equipment.

Class parameter	Value	Inherit
Abstract	YES	
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

Attribute	Domain	Default value	ClassReq.	
condition			NO	NO
performance indicators			NO	NO
age				
remaining useful life			NO	NO
replacement cost			NO	NO

Relation	Multiplicity	Related to	Comments
contains	* - 1	public transportation system	

Name	Subclass of	Superclass of
public transportation equipment	public transportation asset	

Description

Unstationary public transportation assets.

Class parameter	Value	Inherit
Abstract	NO	system
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

Name	Subclass of	Superclass of
public transportation system	transport system	

Description

A set of components that provides transportation service to the public using vehicles that transport more than one person for compensation. Subclasses may include public transit and paratransit systems.

Class parameter	Value	Inherit
Abstract	NO	system
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

Attribute	Domain	Default value	ClassReq.	
number of vehicles			NO	NO

Relation	Multiplicity	Related to	Comment
contains	* - 1	public transportation asset	

Name	Subclass of	Superclass of
rail system	transport system	

Description

An ordered set of rail components. E.g., a railroad.

Class parameter	Value	Inherit
Abstract	NO	system
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

Name	Subclass of	Superclass of
railroad crossing	transportation attachment	

Description

At grade intersection of a railway and a highway.

Class parameter	Value	Inherit
Abstract	NO	system
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

Attribute	Domain	Default value	ClassReq.	
number of trains			NO	NO

Name	Subclass of	Superclass of
railway	transport link	

Description

A dedicated rights-of-way reserved for train travel. includes light rail, heavy rail, rapid rail, commuter rail.

Class parameter	Value	Inherit
Abstract	NO	system
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

Name	Subclass of	Superclass of
recreation area	customer site	

Description

A significant scenic or recreational travel destination.

Class parameter	Value	Inherit
Abstract	NO	system
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

Name	Subclass of	Superclass of
reference network		

Description

A frame of reference, or datum, used to control linear locations. The reference network is used for both field locations and data base representations of those locations.

Class parameter	Value	Inherit
Abstract	NO	system
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

Relation	Multiplicity	Related to	Comments
reference network# anchor point	1 - *	anchor point	
reference network# anchor section	1 - *	anchor section	
represents	* - 1	geographic reference network	

Name	Subclass of	Superclass of
reference post	traversal reference point	

Description

A numbered post placed along a travelway. The number may represent a milepoint or may be arbitrary.

Class parameter	Value	Inherit
Abstract	NO	system
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

Attribute	Domain	Default value	ClassReq.	
number			NO	NO

Name	Subclass of	Superclass of
retaining wall	structure	

Description

A structure used to retain soil.

Class parameter	Value	Inherit
Abstract	YES	
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

Name	Subclass of	Superclass of
rigid pavement	pavement	

Description

A pavement structure which distributes loads to the subgrade having as one course a portland cement concrete slab of relatively high bending resistance.

Class parameter	Value	Inherit
Abstract	NO	system
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

Name	Subclass of	Superclass of
roadway	transportation element	

Description

The portion of a highway designed or built for vehicular use. includes the traveled way, shoulders, gutters and auxiliary lanes.

Class parameter	Value	Inherit
Abstract	NO	system
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

Attribute	Domain	Default value	ClassReq.	
alignment			NO	NO
cross section			NO	NO
number of lanes			NO	NO
traveled way width			NO	NO

Name	Subclass of	Superclass of
roadway experience	experience	roadway treatment

Description

An event that affects the state of a roadway.

Class parameter	Value	Inherit
Abstract	YES	
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

Name	Subclass of	Superclass of
roadway system	component system	

Description

An ordered set of roadway sections.

Class parameter	Value	Inherit
Abstract	NO	system
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

Name	Subclass of	Superclass of
roadway treatment	roadway experience	

Description

An action that alters the state of a roadway. Actions include construction, maintenance and rehabilitation.

Class parameter	Value	Inherit
Abstract	NO	system
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

Name	Subclass of	Superclass of
safety hotspot	transportation attachment	

Description

A location with greater than expected numbers of crashes. A hazardous location.

Class parameter	Value	Inherit
Abstract	NO	system
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

Relation	Multiplicity	Related to	Comments
is a collection of	* - 0-1	crash	

Name	Subclass of	Superclass of
safety section	transportation element	

Description

A location established to monitor crash incidents and establish crash rates.

Class parameter	Value	Inherit
Abstract	NO	system
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

Attribute	Domain	Default value	Class	Req.
number of fatalities			NO	NO
number of injuries			NO	NO
number of vehicles			NO	NO

Name	Subclass of	Superclass of
safety section experience	experience	

Description

Class parameter	Value	Inherit
Abstract	NO	system
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

Relation	Multiplicity	Related to	Comments
contains	* - 1	crash	

Name	Subclass of	Superclass of
safety system	component system	

Description

An ordered set of safety sections

Class parameter	Value	Inherit
Abstract	NO	system
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

Name	Subclass of	Superclass of
section	transportation component	transport link transportation element anchor section

Description

A linear portion of a transportation system or its components defined as the portion of the component located between two sites.

Class parameter	Value	Inherit
Abstract	YES	
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

Relation	Multiplicity	Related to	Comments
locates begin	1 - *	site	
locates end	1 - *	site	

Name	Subclass of	Superclass of
site	transportation component	transport node transportation attachment anchor point

Description

A transportation component that exists or occurs at a specific place.

Class parameter	Value	Inherit
Abstract	YES	
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

Attribute	Domain	Default value	Class	Req.
offset			NO	NO
offset direction			NO	NO

Relation	Multiplicity	Related to	Comments
is addressed by	* - 1	linear references	
locates begin	1 - *	section	
locates end	1 - *	section	

Name	Subclass of	Superclass of
state	phenomenon	transportation component assembly transportation system planning area travel demand

Description

A condition of being defined by constant attributes and link relationships. A state can be thought of as a portion of time between events. A State with no end state is current in when valid time equals system time.

Class parameter	Value	Inherit
Abstract	YES	
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

Relation	Multiplicity	Related to	Comments
begins by	1 - *	event	
ends by	0-1 - *	event	

Name	Subclass of	Superclass of
statewide planning area	planning region	

Description

A territorial unit comprising one of the 50 United States, Puerto Rice, or the District of Columbia..

Class parameter	Value	Inherit
Abstract	NO	system
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

Name	Subclass of	Superclass of
street address	traversal reference point	

Description

A geographic location of a building.

Class parameter	Value	Inherit
Abstract	NO	system
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

Name	Subclass of	Superclass of
structure	transportation element	tunnel bridge noise barrier culvert retaining wall

Description

An engineered works such as bridge, noise barrier, box culvert.

Class parameter	Value	Inherit
Abstract	YES	
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

Name	Subclass of	Superclass of
system demand	transportation system experience	

Description

The actual or latent demand for persons of commodity movement on a transportation system.

Class parameter	Value	Inherit
Abstract	NO	system
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

Name	Subclass of	Superclass of
temporal topology		

Description

See discussion in SAIF release3.1 p. 118 ff.

Class parameter	Value	Inherit
Abstract	NO	system
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

Attribute	Domain	Default value	ClassReq.	
temporal relationship			NO	NO

Relation	Multiplicity	Related to	Comments
phenomenon 1	1 - 1	phenomenon	
phenomenon 2	1 - 1	phenomenon	

Name	Subclass of	Superclass of
terminal	transport node	airport depot port pipeline farm

Description

A facility allowing intermodal transfer of passengers or goods.

Class parameter	Value	Inherit
Abstract	YES	
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

Name	Subclass of	Superclass of
traffic experience	experience	traffic record

Description

An event that alters the state of a traffic section.

Class parameter	Value	Inherit
Abstract	YES	
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

Name	Subclass of	Superclass of
traffic record	traffic experience	

Description

The results of a traffic census.

Class parameter	Value	Inherit
Abstract	NO	system
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

Name	Subclass of	Superclass of
traffic section	transportation element	

Description

A statistical section used to monitor traffic statistics.

Class parameter	Value	Inherit
Abstract	NO	system
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

Attribute	Domain	Default value	Class	Req.
highway traffic volume			NO	NO
vehicle classification			NO	NO
vehicle occupancy			NO	NO
vehicle weight			NO	NO

Name	Subclass of	Superclass of
traffic system	component system	

Description

An ordered set of traffic sections

Class parameter	Value	Inherit
Abstract	NO	system
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

Name	Subclass of	Superclass of
trail	transport link	

Description

A marked or established path used by pedestrians, bicycles or horses, especially through forests or other recreational areas.

Class parameter	Value	Inherit
Abstract	NO	system
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

Name	Subclass of	Superclass of
trail system	transport system	

Description

An ordered set of trails.

Class parameter	Value	Inherit
Abstract	NO	system
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

Name	Subclass of	Superclass of
TRAMMS event	planning event	determine traffic state event determine bridge state event determine pavement state event determine roadway state event determine safety state event

Description

An activity that is part of the Transportation Modelling and Monitoring Business System.

Class parameter	Value	Inherit
Abstract	YES	
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

Name	Subclass of	Superclass of
transit route	traversal	

Description

A designated, specified path to which a transit vehicle is assigned.

Class parameter	Value	Inherit
Abstract	NO	system
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

Name	Subclass of	Superclass of
transit stop	traversal reference point	

Description

An area where passengers wait for, board, alight and transfer between transit units. It is indicated by distinctive signs or pavement and curb markings.

Class parameter	Value	Inherit
Abstract	NO	system
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

Attribute	Domain	Default value	ClassReq.	
time point			NO	NO

Name	Subclass of	Superclass of
transport link	section	continuous flow facility waterway bikeway trail pedestrianway railway busway highway

Description

A transport link is and historical, exisitng or anticipated travelway used to transport passengers or goods.
The direction of the links establishes the primary direction in which the traversal is said to "run."

Class parameter	Value	Inherit
Abstract	YES	
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

Attribute	Domain	Default value	ClassReq.	
units			NO	NO
weight			NO	NO

Relation	Multiplicity	Related to	Comments
from	1 - *	transport node	
to	1 - *	transport node	
transport link# transport system	* - 1	transport system	
transport link# traversal	* - *	traversal	A traversal is an ordered and directed ("head to tail") sequence of transport links belonging to the same transportation system. Multiple traversals may use the same transportation

OMT module : fits6mod Module modified : Wed Mar 29 09:28:22 1995
Class name : transport link experience Report page : 1 Overall page : 136

Name	Subclass of	Superclass of
transport link experience	experience	link demand

Description

Class parameter	Value	Inherit
Abstract	NO	system
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

OMT module : fits6mod Module modified : Wed Mar 29 09:28:22 1995
Class name : transport node Report page : 1 Overall page : 137

Name	Subclass of	Superclass of
transport node	site	terminal junction customer site

Description

A transport node is a place where travel originates (or ends) or a facility allowing for a change in transportation mode or travel route.

Class parameter	Value	Inherit
Abstract	YES	
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

Relation	Multiplicity	Related to	Comments
from	1 - *	transport link	
is located on	1 - *	anchor section	
to	1 - *	transport link	

Name	Subclass of	Superclass of
transport node experience	experience	node demand

Description

Class parameter	Value	Inherit
Abstract	NO	system
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

Name	Subclass of	Superclass of
transport system	transportation system	highway system water transport system rail system continuous flow system public transportation system trail system pedestrian system intermodal system bikeway system

Description

A transport system is an ordered collection of transportation components serving a transportation function in support of transportation objectives (i.e., a FITS).
These systems can be single mode (eg., highway systems), multi-modal (eg., public transportation buses + light rail) or intermodal (eg., freight or passenger based).
The default transport system consists of all transportation choices within a predetermined region.

Class parameter	Value	Inherit
Abstract	YES	
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

Relation	Multiplicity	Related to	Comments
is assigned to	* - 1	travel demand	
is indexed by	* - 1	traversal	
is served by	* - 1	planning area	
is set for	* - 1	objective	
transport link# transport system	* - 1	transport link	

OMT module : fits6mod Module modified : Wed Mar 29 09:28:22 1995
Class name : transport system link Report page : 1 Overall page : 140

Name	Subclass of	Superclass of
transport system link	assembly	

Description

An object responsible for maintaing the assemblies of transport systems and their links.

Class parameter	Value	Inherit
Abstract	NO	system
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

OMT module : fits6mod Module modified : Wed Mar 29 09:28:22 1995
Class name : transport system node Report page : 1 Overall page : 141

Name	Subclass of	Superclass of
transport system node	assembly	

Description

Class parameter	Value	Inherit
Abstract	NO	system
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

OMT module : fits6mod Module modified : Wed Mar 29 09:28:22 1995
Class name : transportation attachment Report page : 1 Overall page : 142

Name	Subclass of	Superclass of
transportation attachment	site	trn service center railroad crossing fixture air quality hotspot safety hotspot traversal reference point highway traffic counter

Description

A site of interest or facility associated with a transportation system that is not an element of a system.

Class parameter	Value	Inherit
Abstract	YES	
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

OMT module : fits6mod Module modified : Wed Mar 29 09:28:22 1995
Class name : transportation complex Report page : 1 Overall page : 143

Name	Subclass of	Superclass of
transportation complex		

Description

A collection of interconnected transportation components. Complexes are used to manage groups of components i.e. act as "containers." They are the primary mechanism for determining multi-component performance. e.g., pavement sections may collaborate with the traffic section complex

Class parameter	Value	Inherit
Abstract	NO	system
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

Relation	Multiplicity	Related to	Comments
collaborates with	1 - *	transportation complex	
collaborates with	1 - *	transportation complex	
is a collection of	* - 1	transportation component	
transportation complex# transportation system	* - 1	transportation system	

Name	Subclass of	Superclass of
transportation component	state	site
		section

Description

An object regarded as part of a transportation system.

Class parameter	Value	Inherit
Abstract	YES	
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

Attribute	Domain	Default value	Class	Req.
name			NO	NO

Relation	Multiplicity	Related to	Comments
alters	1 - *	experience	
component 1	1 - 1	linear topology	
component 2	1 - 1	linear topology	
is a collection of	* - 1	transportation complex	

Name	Subclass of	Superclass of
transportation element	section	traffic section
		pavement
		roadway
		structure
		safety section

Description

Any transportation related object that affects or monitors the availability, quality or performance of transportation functions or services.

Class parameter	Value	Inherit
Abstract	YES	
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

Name	Subclass of	Superclass of
transportation system	state	component system
		transport system

Description

An ordered set of transportation components.

Class parameter	Value	Inherit
Abstract	YES	
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

Attribute	Domain	Default value	ClassReq.	
name			NO	NO

Relation	Multiplicity	Related to	Comments
defines a transportation system network	1 - *	network topology	
contains	* - 1	experience	
is composed of	1 - *	transportation system	
is composed of	1 - *	transportation system	
transportation complex# transportation system	* - 1	transportation complex	

Name	Subclass of	Superclass of
transportation system experience	experience	system demand

Description

A experience that alters the state of a transportation system.

Class parameter	Value	Inherit
Abstract	YES	
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

Name	Subclass of	Superclass of
travel analysis zone	planning area	

Description

A division of a study area used for travel demand analysis purposes. A planning region is divided into zones, the number and size of which depend on land uses in the area, transportation access, census boundaries and political boundaries.
Zone boundaries are defined so that land uses and activities are homogeneous, to the extent practicable. Travel analysis zones may be coincident with census blocks.

Class parameter	Value	Inherit
Abstract	NO	system
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

Attribute	Domain	Default value	Class	Req.
employment			NO	NO
land use			NO	NO
population			NO	NO

Relation	Multiplicity	Related to	Comments
travel analysis zone#planning area	1 - *	planning area	

Name	Subclass of	Superclass of
travel demand	state	

Description

The actual or latent movement of people or freight between two points for a specific purpose. Each trip (or aggregation of trips is characterized by mode choice.

Class parameter	Value	Inherit
Abstract	NO	system
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

Relation	Multiplicity	Related to	Comments
is assigned to	* - 1	transport system	

Name	Subclass of	Superclass of
		transit route highway route freight distribution route

traversal

Description

The geographical route, path or course designated for travel or followed by a vehicle or traveler.
Traversals also may be names of designated paths through a transportation system.
Examples include mainline routes, business routes, spurs, county routes, scenic, hazmat.

Class parameter	Value	Inherit
Abstract	NO	system
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

Attribute	Domain	Default value	ClassReq.
traversal metric			NO NO

Relation	Multiplicity	Related to	Comments
is indexed by	* - 1	transport system	
linear references# traversal	1 - *	linear references	
transport link# traversal	* - *	transport link	A traversal is an ordered and directed ("head to tail") sequence of transport links belonging to the same transportation system. Multiple traversals may use the same transportation links.
traversal reference point#traversal	1 - 1	traversal reference point	

Name	Subclass of	Superclass of
traversal link	assembly	

Description

An object responsible for maintaining the history of traversal and link assemblies.

Class parameter	Value	Inherit
Abstract	NO	system
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

Name	Subclass of	Superclass of
trn service center	transportation attachment	

Description

The area and service used to enhance, regulate or respond to transportation. Examples include traffic control centers, police and other dispatch centers, weigh-in-motion sites, toll plazas, tourist rest areas.

Class parameter	Value	Inherit
Abstract	YES	
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

Name	Subclass of	Superclass of
tunnel	structure	

Description

An enclosed passageway through or under an obstruction such as a city, river, mountain, or harbor.

Class parameter	Value	Inherit
Abstract	YES	
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

Name	Subclass of	Superclass of
traversal reference point	transportation attachment	transit stop
		reference post
		street address

Description

A point on a traversal that can be easily identified and whose identity and location are known.

Class parameter	Value	Inherit
Abstract	NO	system
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

Attribute	Domain	Default value	ClassReq.	
description			NO	NO

Relation	Multiplicity	Related to	Comments
is referenced by	1 - *	linear references	
traversal reference point#traversal	1 - 1	traversal	

Name	Subclass of	Superclass of
TREADS event	planning event	

Description

An activity that is part of the Treatment Development Business System.

Class parameter	Value	Inherit
Abstract	YES	
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

OMT module : fits6mod Module modified : Wed Mar 29 09:28:22 1995
Class name : water transport system Report page : 1 Overall page : 156

Name	Subclass of	Superclass of
water transport system	transport system	

Description

An ordered set of marine transport components.

Class parameter	Value	Inherit
Abstract	NO	system
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

OMT module : fits6mod Module modified : Wed Mar 29 09:28:22 1995
Class name : waterway Report page : 1 Overall page : 157

Name	Subclass of	Superclass of
waterway	transport link	

Description

A navigable water course, including canals, used for the transport of people or goods.

Class parameter	Value	Inherit
Abstract	NO	system
Unique fields	YES	
Unique operations	YES	
Primary key impl.		system
Candidate keys		system
Indexes		system
Primary key		system

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2 University of New Mexico
Alliance for Transportation Research
ATTN: David R. Fletcher
1001 University Blvd. SE, Suite 103
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2 New Mexico State Highway and Transportation Dept.
ATTN: Thomas Henderson
1120 Cerrillos Road, SB-3
Santa Fe, New Mexico 87504-1149

2 University of Wisconsin-Madison
Department of Civil and Environmental Engineering
ATTN: Alan Vonderohe, T. Hepworth
1208 Engineering Hall
Madison, WI 53706

1 Oak Ridge National Laboratory
ATTN: Stephen R. Gordon
P.O. Box 2008
Bldg. 4500N, MS 6270
Oak Ridge, TN 37831

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Bureau of Transportation Statistics
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